Monitoring Plant Performance at Two Restored Beaches: Bowman and Cornet Bay Deception Pass State Park, WA

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Abstract

Backshore plant communities in the Puget Sound region are subject to degradation due to the effects of shoreline armoring however ecological restoration has emerged as a viable solution to the degradation of this ecosystem, in many cases requiring the removal of beach armoring, re-grading of beach slopes and the installation of marine riparian plant species to restore ecosystem processes. This research utilized a citizen science program to gather data from two recent restoration projects, Bowman Bay and Cornet Bay, in Deception Pass State Park, WA to determine the progress and state of installed vegetation and to provide recommendations for future management. Data were gathered on several parameters including plant cover, density, and survivorship. This study found that both Bowman and Cornet Bay have a significant percentage of bare ground, indicating that re-planting should occur in winter or early spring of 2018. Additionally, non-native invasive species, though present in low numbers, need to be addressed through continued on-site maintenance actions. Overall, monitoring should continue in order to further identify and evaluate plant performance and provide a point of reference to develop adaptive management solutions to potential challenges.

Introduction

Puget Sound nearshore environments are dynamic and complex, constantly evolving in response to numerous abiotic factors such as the complexities of tidal currents, wind influenced wave patterns and human disturbances (WDNR 2014). Anthropogenic impacts such as deforestation along marine waters and shoreline modifications such as beach armoring have reduced natural sediment deposition processes and threaten habitat for salmonids (Lynn 1998). Thus, the survival of near and backshore coastal ecotones and many of their associated species depend on preservation, restoration and proper management. The purpose of this study is to gather data on plant performance and progress of two nearshore restoration sites, Bowman Bay and Cornet Bay at Deception Pass State Park, WA in order to prepare recommendations for future management (Figure 1).

Figure 1: Deception Pass State Park, WA Park Boundary and Study Sites

Deception Pass State Park Boundary and Study Sites

Nearshore ecosystems of the Puget Sound are currently experiencing a variety of threats. Many factors have contributed to this decline including development, which disrupts natural hydrologic processes, non-point source pollution from storm water runoff and habitat loss in the upland and adjacent marine areas (Lynn 1998). The significant loss of nearshore habitat has especially impacted marine riparian areas and adjacent marshes (Levings and Thom 1994). This is evident through the listing of Puget Sound species under the Endangered Species Act (ESA) as approximately 9 out of the 10 species listed inhabit the nearshore (Fresh *et al* 2011).

As this trend continues, increased attention is being paid to the natural processes that shape Puget Sound, including the importance of the backshore and its functions. This includes sediment transport and material exchange from the uplands to the intertidal zone as well as interruptions to those processes by anthropogenic forces (Fresh *et al.* 2011). As result of this, ecological restoration techniques have emerged as a viable solution to the degradation of this ecosystem, in many cases requiring the removal of beach armoring, regrading of beach slopes and the installation of marine riparian plant species to restore natural ecosystem processes. This has resulted in increased awareness of the public, land managers and policy makers of the issue, culminating in preservation and restoration efforts concentrated within the Puget Sound nearshore environment.

Objectives

Since current projects often use past projects as models, determining the performance of past projects in terms of stated management objectives is important. If these past projects have not met their goal, understanding why is essential to improve restoration methods and techniques. This study will provide necessary data to determine if plant survival management objectives for Bowman and Cornet Bay have been met and will produce recommendations for the future management of these restoration projects.

This study evaluated each restored area by measuring plant cover, density and survivorship. This research addressed several questions including: 1) Was the restoration effort successful in meeting the goals for native plant species establishment on site? 2) Is long term monitoring necessary? 3) What recommendations for future Puget Sound nearshore restoration projects can be drawn from data gathered on plant survival and progress at Bowman and Cornet Bay?

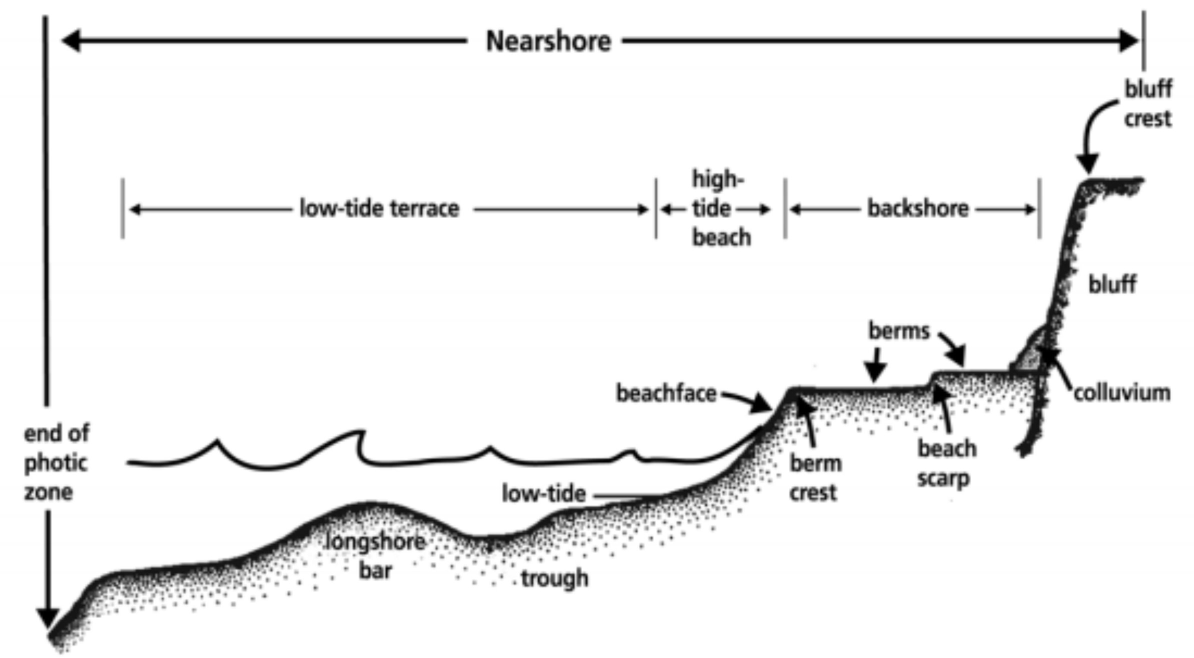
Related Research

Definition

Located at the interface between marine and terrestrial ecosystems, the nearshore extends offshore to the photic zone and landward to extreme MHHW, which includes both intertidal and subtidal areas (Cereghino *et al* 2012). This zone includes unvegetated rocky and sandy shores, mudflats as well as eelgrass, kelp and intertidal algal beds (Lynn 1998). In contrast, the backshore zone is located within the supratidal zone, which receives occasional salt splash and is inundated only during extreme tide and storm events. This zone is composed of marine riparian vegetation whose role provides valued ecosystems services and ecological functions (Figure 2). Despite the complex role backshore plant community's play in nearshore ecosystem processes, the role of marine riparian vegetation has received scant research attention (Brennon & Culverwell 2004). Much information on the subject comes from studies of outer-coastal and dune environments, which are generally different systems than the more protected Puget Sound backshore. If marine riparian plant communities are discussed, it is usually as an aside to more central research questions, such as geomorphology or effects on fish habitat. Until recently, the definition of a riparian area did not include marine waters. Due to the lack of a consistent definition, which was identified as a major problem of federal and state programs that might manage and protect these areas, the National Resource Committee (NRC 2002) developed the following definition:

"Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes, and estuarine-marine shorelines" (NRC 2002).

Figure 2: Diagram of the nearshore



Source: (Johannessen and MacLennan 2007)

Backshore marine riparian areas can be further defined as the accretion zone, the area located just above MHHW, which terminates in an upland edge. Sediments and windblown material accumulate over time providing a soil substrate that is fast draining and usually lacking in organic matter (NRCS 1989). Vegetation colonizing the area can withstand salt spray and periods of flooding during extreme tide and inundation events.

Processes

Backshore marine riparian vegetation is a transitional area influenced by both upland and marine habitats. This zone is marked by the accumulation of organic matter and overhanging vegetation, such as *Arbutus menziesii* and *Pseudotsuga menziesii* which provides habitat and cover for both terrestrial and marine organisms (Brennon 2007).

Mixed semidiurnal tides, meaning two high and two low tides influence hydrology in the nearshore each lunar day, ranging from 10 ft. to -1 foot at low tide in the north Puget Sound region (WDNR 2014). In its natural state, wave action can be absorbed by vegetation and large woody debris (Brennon & Culverwell 2004). Groundwater discharge also plays a role in this system, as unconfined aquifers are connected hydraulically to the sea through permeable beach sediments (McLachlan & Brown 2006).

The general geological processes, which help to shape the backshore, are primarily sediment deposition and erosional processes. This involves the gradual accumulation of wave and wind generated sediment in the area above MHHW (WDNR 2014). Berms can form in these areas by a combination of forces. For instance, Finlayson (2006) attributes large woody debris and backshore vegetation as the primary drivers in berm formation due to their ability to trap and accumulate substrate thereby buffering wave energy above MHHW thus preventing erosion of habitat. Additionally, winter storms and spring high tides also contribute to berm formation (Downing 1983).

The substrates of the backshore are generally composed of various sized cobble and sand particles (Dethier *et al.* 2010). Soils tend to be low in organic matter and are primarily comprised of beach sand parent material (NRCS 1989, NRCS 2008, Soil web app 2017). Soil infiltration rates are quick due to sandy textures that limit the ability to retain water.

Fauna

Organic detritus such as leaves and overhanging vegetation from terrestrial plants fall onto the backshore forming the basis for multiple terrestrial and aquatic food webs. The backshore receives important inputs of seaweeds and marine-based detritus, which are consumed by terrestrial and semi- terrestrial invertebrates (Dugan *et al.* 2011). This in turn is consumed by many species of birds, transferring much of that energy to the uplands (Downing 1983; Brennan 2007; Dugan *et al.* 2008). For instance, several bird species nest, roost, and/or overwinter in the backshore zone including gulls, seabirds such as plover, and smaller birds like longspurs and buntings (Dethier *et al.* 2010).

Important decomposers in the nearshore system for nutrient cycling are the talitrid, beach hopper amphipod (Dethier *et al*. 2010). Tonnes (2008) found that amphipods are strongly associated with driftwood also known as large woody debris (LWD) since it provides protection from predators, favorable temperature and moisture conditions. Organic matter is also abundant for consumption. Other wildlife may only use marine riparian areas as paths for migration or at certain life stages.

Flora

According to Machalachen and Brown (2006), the flora of marine riparian areas can be characterized by degrees of zonation. Zone 1 is the area closest to the sea, referred to as the pioneer zone. Grasses and succulents, which primarily rely on rhizomatous and stoloniferous growth forms, dominate since they can withstand the high level of disturbance in the nearshore. This includes shifting sand, temperature extremes and high salt loads. Seed dispersal is primarily achieved through wind and water. Zone 2 is the shrub community, which includes annuals and perennials but which also includes forbs, creepers and succulents. Seed dispersal is primarily achieved through birds and wind although bird-dispersed seed increasingly invades this zone as it ages. Zone 3 is referred to as the thicket zone and is made up of dwarf trees and shrubs. This zone is shaped by wind, yielding a flat canopy, known as wind pruning. This zone develops in areas that receive at least 250mm of rainfall a year and birds are the primary mode of seed dispersal. Zone 4 is referred to as the forest zone and is defined by a closed canopy with shrubs and/or thicket species dominating the understory. This zone thrives in areas that receive annual rainfalls of up to 700mm. Birds represent the primary mode of seed dispersal.

Functions and Benefits

Marine riparian areas provide fundamental ecological functions that assist in the protection and health of adjacent marine water bodies. This is based on the extensive research of the functions of freshwater riparian systems. In many ways, the functions of these two systems are similar, however marine riparian vegetation provides functions that are unique to nearshore ecosystems such as biogeochemical processes, ocean influences and differences in the biota between fresh and marine environments.

Water quality functions are facilitated by soils and vegetation. Vegetation ameliorates nutrient and pollutant inputs into adjacent waters by stabilizing soils thereby reducing erosion, transforming nutrients and trapping sediment (Brennon 2007). Fine sediments become exposed and therefore subject to erosion due to vegetation removal, excavation and compaction of soils. Therefore the installation of marine riparian vegetation slows the flow of surface water, contributing to higher residence times, decreasing surface flows and the chance of erosion (May 2003).

Terrestrial and marine vegetative inputs primarily fuel nutrient cycling in this system. This influences both the species present and their ecological function (Valiela 2015). Forms of organic debris from terrestrial vegetation that support these functions include wood, leaf litter and other organic matter, which is transformed into nutrients that support the marine food web (Brennon 2007).

The value of shading is also an important function within the marine riparian system. Foliage intercepts solar inputs creating microclimatic conditions, which affect air temperature, soil moisture, wind speeds and humidity (May 2003, Chen *et al* 1999). Terrestrial and aquatic microclimates are influenced by shade and temperature fluctuations that can negatively impact both aquatic and terrestrial organisms, particularly those that can only survive within a relatively narrow range of temperature and moisture conditions (Brennan 2007). For instance, lack of shade on surf smelt spawning beaches results in higher temperatures, drier conditions and increased egg mortality (Pentilla 2001; Rice 2006).

In marine ecosystems LWD is recruited from windstorms, wave action and landslides (NRCS 1996). These inputs provide important benefits such as the accumulation of detritus serving as a food source and habitat for invertebrates. This in turn supports terrestrial vegetation (similar to the function of nurse logs in the upland), providing structural complexity for fish and wildlife habitat. Additionally, LWD also traps sediment, which assists in stabilizing banks thus providing erosion control (Tonnes 2008).

Disturbance

Roughly 4 million people, or 65 percent of the Washington State population, live in the Puget Sound watershed (OFM 2017). This illustrates the extent to which humans have chosen to live near aquatic resources and as a result, backshore areas tend to be highly modified (Broadhurst 1998).

Shoreline armoring, the practice of constructing bulkheads (seawalls) and rock revetments, interferes with sediment deposition processes, accumulation of beach wrack and natural erosive processes (Dugan *et al.* 2011). The Puget Sound Partnership has identified 666 miles of Puget Sound shoreline that has been armored, or 27% of the total shoreline length (PSP 2017). By installing beach armoring, natural vegetation must be cleared which destroys backshore habitat and increases erosion. (Broadhurst 1998). Additionally, these structures physically destroy reproductive habitat for Surf smelt (*Hypomesus pretiosus*) and decrease habitat for juvenile salmonids (Beamer & Fresh 2013). The highly modified environment that remains increases the threat of invasive plant species such as *Spartina* spp. (cordgrass). Such species can cause extensive ecological damage and economic costs while decreasing populations of native species (Brennon 2007).

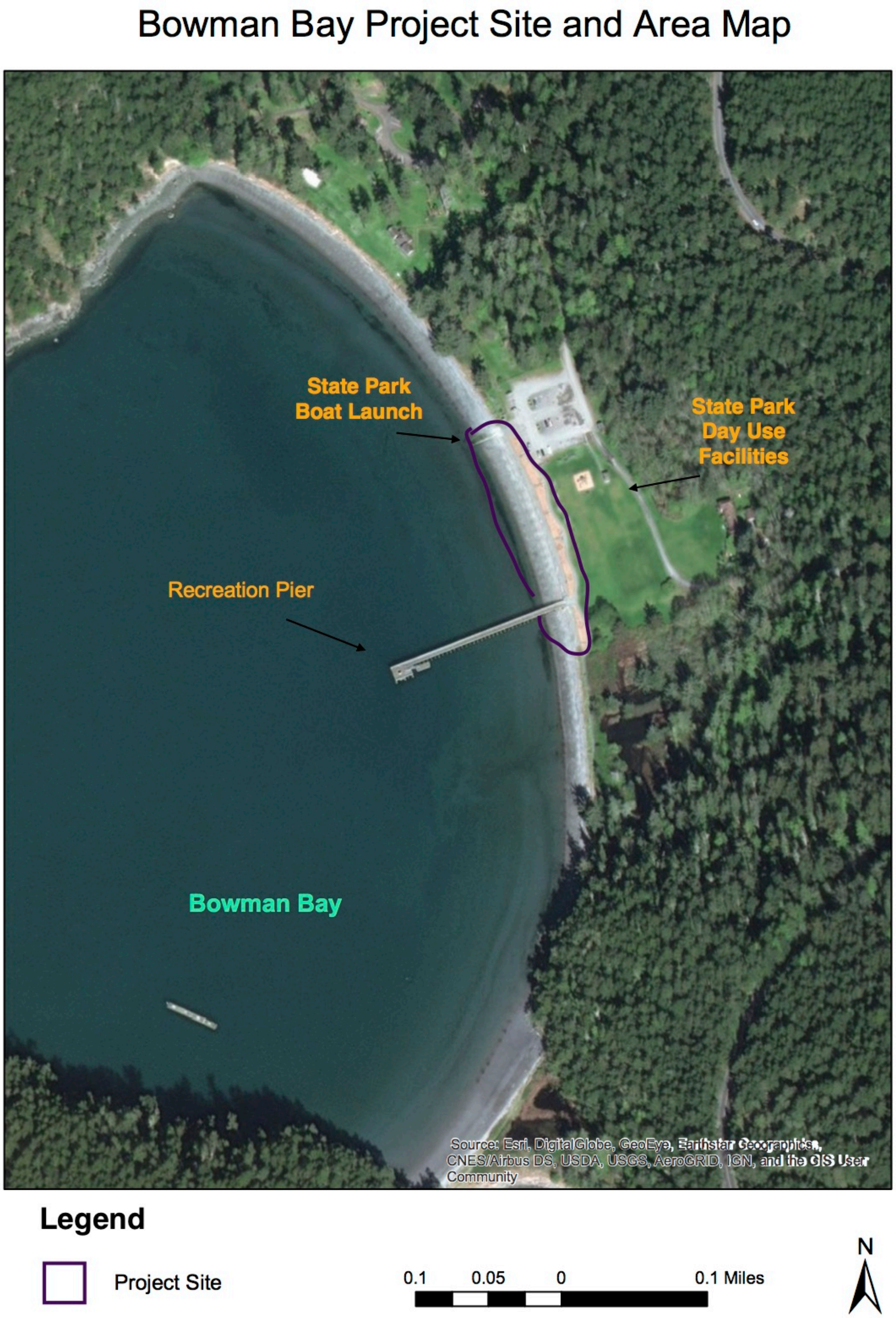
Background

Site Description

Bowman Bay

Bowman Bay is a day use and camping area in Deception Pass State Park, which is located on the southwestern shore of Fidalgo island on Rosario Strait. The deep, narrow channel of Deception Pass is located just south of the site, which brings strong tidal currents and nutrient upwelling to the area (Blue, Johannessen & MacLennan 2014). The bay itself is a 2,100-foot pocket beach which faces west-southwest and is exposed to approximately 70 miles of fetch (open water distance from which waves form). This exposes the site to wind generated waves over a high-energy exposure in addition to ocean swell that has been slightly diminished as it goes through the Strait of Juan de Fuca. The beach is composed primarily of gravel and is termed a swash aligned beach meaning waves break in line and parallel to the coast. Thus, wave energy moves material up and down the beach, forming a steep gradient due to sediment deposition processes. The beach has a moderately steep slope (5:1 to 6:1; H:V) for a beach in the Puget Sound region (Blue, Johannessen & MacLennan 2014). A storm berm, an accretionary feature comprised of coarse gravel, is present 100 feet from mean higher high water (MHHW). The beach face is composed of sand and gravel. A wooden pier extends into the water for 450 feet to provide recreational access and a concrete boat ramp is also present (Figure 3). In contrast, the upland area is composed of a gravel parking lot, playground, expansive lawn and a network of trails.

Figure 3: Bowman Bay Project Site Map and Area



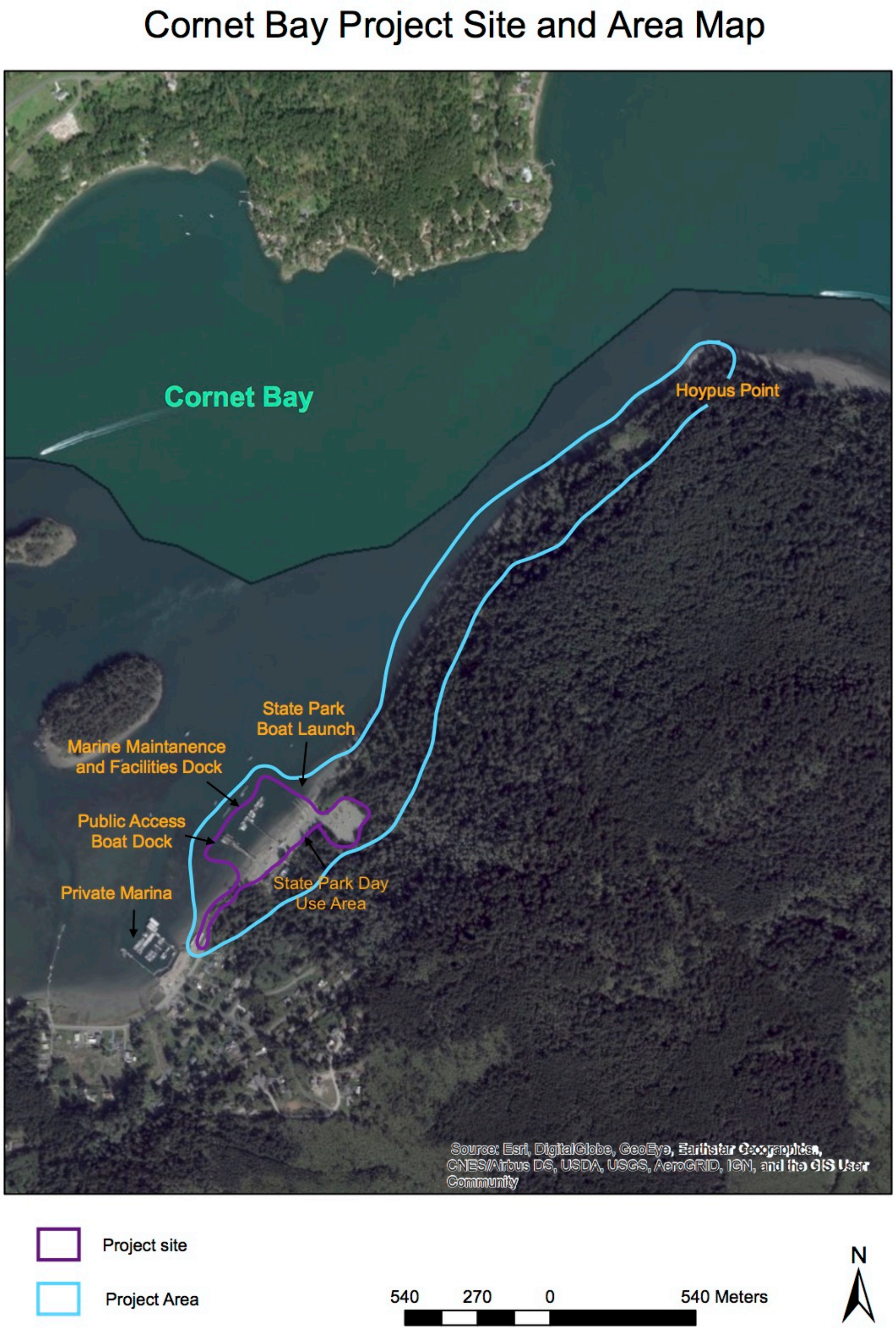
The two main issues specific to this project were the effects of beach armoring and loss of marine riparian vegetation. Beach armoring was installed to protect a marine biological station in the 1970's. This inhibited beach processes such as sediment dynamics, which decreased moisture retention (Blue, Johannessen & MacLennan 2014). Additionally, the beach armor was dissipating wave energy, negating the ability of large woody debris (LWD) and beach wrack to accumulate. This results in a coarsening of beach sediment, which minimizes reproductive habitat for Surf smelt (*Hypomesus pretiosus*) (Beamer and Fresh 2013). Pocket beaches, such as Bowman Bay, have been found to be highly utilized by juvenile salmonids, Chinook salmon (Oncorhynchus tshawytscha), Chum salmon (Oncorhynchus keta) and juvenile forage fish such as Surf Smelt (*Hypomesus pretiosus*) (Beamer & Fresh 2013). Physical and ecological functions were also being impacted by beach armoring such as sediment transport and deposition, salmon production, forage fish spawning, clam production, eelgrass and insect growth (Blue, Johannessen & MacLennan 2014). The goal of the restoration was to remove the riprap and re-grade the beach thus improving sediment deposition, large woody debris and beach wrack accumulation. Additionally, the installation of marine riparian vegetation will assist in providing erosion control and wildlife habitat.

After the bulkhead removal and subsequent beach regrading, plant installation was initiated in 2015 and completed with the assistance of a school workparty on Earth Day in 2016. The total area re-vegetated was .26 acres with a total of 2,473 plants installed (Appendix 1). Additional plants were installed in the winter of 2017 (Appendix 2). The planting area was divided into two distinct zones. Zone 2 is designated as a beach grass community and thus expected to experience tidal inundation during extreme tide and storm events. Zone 3 is the highest elevation planting, characterized by a backshore tree and shrub community. The Bowman Bay site was monitored by Skagit Fisheries Enhancement Group staff, a UW graduate student, vegetation monitoring interns and citizen scientist on June 3rd, 13th and 14th 2017.

Cornet Bay

Cornet Bay is a day use recreation area within Deception Pass State Park, which is located on the northernmost end and on the eastern side of Whidbey Island. The bay itself is a pocket estuary or embayment that connects Skagit Bay to the Strait of Juan de Fuca. The bay extends out to Hoypus Point in the northeast and is bounded in the north by Ben Ure Island and Goose Island (Herrera Environmental consultants 2009). The deep, narrow, channel of Deception Pass is located just north of the site. Extensive mudflats are present at the head of Cornet Bay and both sides of the bay are forested. The beach slope at the focal site is between 7:1 and 8:1 (H:V) which is typical of Puget Sound beaches (Herrera Environmental Consultants 2009). The beach substrate is gravel sand. A series of in-water structures are present such as a concrete boat ramp, a small private marina and a marine maintenance and facilities dock, which extends 300 feet into the bay (Herrera Environmental Consultants 2009) (Figure 4). In contrast, the upland area is comprised of an expansive parking lot, picnic areas, restroom facilities and a large network of trails.

Figure 4: Cornet Bay Project Site and Area Map



The two main issues specific to this project were the effects of the bulkhead and loss of marine riparian vegetation. The bulkhead was constructed to protect the fill installed on the backshore to create an elevated day-use area and parking lot (Herrera Environmental Consultants 2009). Like other shoreline armoring in Puget Sound, this bulkhead results in a coarsening of beach sediment in front of the bulkhead by increasing turbulence, thus mobilizing and washing away finer sediment (Herrera Environmental Consultants 2009). This decreases the total volume of beach sediment and creates a mixture of fine and coarse sediments, unsuitable for forage fish spawning such as Surf smelt (*Hypomesus pretiosus*) (Johannsen & Maclennon 2007). Increasing turbulence and wave energy also degrades the nearshore habitat for juvenile Chinook salmon (Oncorhynchus tshawytscha), which favor nearshore habitats with low wave energy, shallow water and fine-grained substrates such as silts and mud (Fresh *et al* 2006). Lack of riparian vegetation along most of the project length decreased the value of the shoreline for a variety of marine and intertidal species (Herrera Environmental Consultants 2009). For instance, the presence of riparian vegetation creates more food choices for salmon by hosting insects upon which salmon prey. The goal of the restoration project was to remove the bulkhead, regrade the beach to a more natural topography and install marine riparian vegetation.

The Cornet Bay Restoration Project was divided into two phases. Phase 1 was completed in 2013 while the final installation of Phase 2 was completed in the spring of 2016. The total area re-vegetated in Phase 1 was just over 1 acre with a total of 6,067 plants installed (Appendix 3). Additional plants were installed in winter 2017 (Appendix 4). In Phase 2, the total area of revegetation was .4 acres or approximately 300 feet of shoreline. Approximately 1,265 native plants were installed (Appendix 5). Additional plants were installed in winter 2017 (Appendix 2). In each Phase, 4 zones comprised of distinct plant communities with similar planting schemes were delineated. Skagit Fisheries Enhancement Group staff, a UW graduate student, vegetation monitoring interns and citizen scientists monitored vegetation. Phase 1 of Cornet was monitored on July 27th, August 9th, 16th and 17th, and September 5th and 7th. Phase 2 was monitored on July 25th - 27th.

Planting Zones

Using a combination of McLachlan & Brown (2006), as-built reports for each project and personal observations the following descriptions characterize each planting zone and the general conditions found therein at both Bowman Bay and Cornet Bay.

Zone 1-Tidal inundation

This is the intertidal zone, a high energy/high traffic area that is un-vegetated and not expected to support plant growth. Therefore this zone was not planted.

Zone 2- Dunegrass community

This zone is located closest to the sea and is the lowest elevation planting. Due to this, periods of tidal inundation during extreme tide and storm events is expected. Plants consist primarily of *Leymus mollis* and *Argentina egedii*. Yet succulents such as *Salicornia virginica* and *Cakile maritima* are also present. Plants in this zone are characterized by rapid growth in order to outpace sand accumulation, succulence to store water, cuticular protection against salt loading and glands to exude salt (McLachlan and Brown 2006). The elevation of this planting in relation o MLLW is 10.1 feet - 10.7 feet.

Zone 3- Backshore shrub community

This area is located within the extreme high tide range at both Bowman Bay and Cornet Bay. Vegetation installed was planted with species that can withstand salt spray and occasional inundation by extreme tide and storm events. Plants are composed of low growing shrubs, sedges, rushes and forbs; for instance *Gaultheria shallon*, *Scirpus americanus*, *Juncus balticus* and *Grindelia integrifolia*. The elevation of this planting in relation to MLLW is 11.5 feet - 12.5 feet.

Zone 4-Shoreline Fringe Forest

The forest zone is the highest elevation planting and is not expected to receive saltwater inputs. This zone blends with the upper edge of zone 3. Plant species installed include *Thuja plicata* and *Picea sitchensis*. The elevation of this planting is more than 12.5 feet.

History

Deception Pass State Park resides in the traditional territory of the Samish Indian Nation and Swinomish Tribal Community, both of which are federally recognized by the United States

Department of the Interior. (Theresa Trebon, personal communication 2018). Cultural practices are similar to other Coast Salish people, in so far as the importance of natural resources are recognized in actions such as hunting and gathering from forests, sea and land (Theresa Trebon, personal communication 2018). Bowman Bay is an area of extreme importance for both tribes, with cultural celebrations held at the beach every year. The Maiden of Deception Pass is a totem, which represents the story of Ko-Kwal-alwoot, a legend of the Samish people. This legend is not a creation story but rather a defining story, which ties the Samish people to Fidalgo Island, and the rich resources the Salish Sea has to offer (Karsen and Rector 2015). Both the Samish Indian Nation and Swinomish Tribal Community are essential to the restoration of Bowman and Cornet Bay, as they are co-managers of the State Park resource. Additionally, both tribes play a critical role in the restoration of salmon runs.

Captain Salvador Fidalgo of Spain described the first written record of Deception Pass in 1792. The legacy of this expedition is immortalized through Spanish names in the park vicinity such as Fidalgo Island and Rosario Beach (Washington State Parks 2018). Captain George Vancouver of England also explored the region at about the same time, giving the name “Deception” to the pass that separates Fidalgo Island from Whidbey Island. This was due to his belief that the pass was a river mouth. It wasn’t until his lieutenant, Joseph Whidbey, sailed through the narrow pass and then south that he discovered the landform was actually an island. Thus, Vancouver realized he had been deceived and Deception Pass was named (Washington State Parks 2018). The adjacent landform was called Whidbey Island after his lieutenant, Joseph Whidbey.

Prior to becoming a state park, the area of Deception Pass was set aside by the government for use as a military reservation in the early 1900's (Deception Pass Park Foundation 2018). President Calvin Coolidge officially signed the deed to the park and Deception Pass State Park was officially designated as a public property for recreation in 1923 (Washington State Parks 2018). Although the area was regularly visited, no infrastructure existed at the park until the beginning of the 1930's, when the Civilian Conservation Corps (CCC) began construction to make the park a reality (Deception Pass Park Foundation 2018). The CCC built roads, the construction of bathroom and picnic facilities, trail building and other infrastructure. The Deception Pass Bridge was completed in July 1935, which connects Fidalgo Island to Whidbey Island.

Currently, Deception Pass State Park is the most visited State Park in Washington State (Washington State Parks, 2018).

Methodology

Vegetation monitoring protocols for Bowman Bay and Cornet Bay were developed and executed by Skagit Fisheries Enhancement Group (SFEG), a non-profit organization located in Mount Vernon, WA. SFEG manages the vegetative component of various restoration projects in Skagit County and the vicinity, which includes native plant installation, monitoring and evaluation. Monitoring is executed with the assistance of volunteers, known as citizen scientists, in addition to student interns. However participation is reliant on completion of a mandatory training program.

The vegetation monitoring training program for the 2017 field season was held on June 3rd at Bowman Bay in Deception Pass State Park. This provided potential volunteers with the basics of botanical terminology and an overview of monitoring methods used at various plant monitoring sites managed by SFEG. Volunteers then practiced using botanical keys and identifying 1-gallon native nursery plants. The option was then given to practice their skills in the field by identifying plants at the Bowman Bay restoration site by measuring height and applying a survivorship rating to individually installed plants. The training session lasted about three hours at which point volunteers could stay to continue to collect data in the field at Bowman Bay.

Currently, the use of citizen scientists in data collection represents a burgeoning field wherein the public is enlisted for scientific research. This allows unprecedented access to locations, interactions with people in the subject area and at scales otherwise not possible; rendering citizen science programs increasingly important to environmental research (Dickinson 2012).

Yet questions on data validity and strategies to improve accuracy and precision of collected data, represents the primary conversation on the subject. An educational component most often in the form of training sessions allows citizen scientists to become familiar with the subject while practicing field techniques. Lukyanenko (2016) reports that the use of flexible protocols allows for more “discoveries” or precision in reporting. For instance, a volunteer who went beyond the defined task was able to contribute valuable information to the project thus raising the question of how many other volunteers noticed the same thing but failed to report it. In this case, relaxing instructions and providing an arena for personal observation may improve the precision of collected data. The use of paired sampling is also a technique currently in use to check the accuracy of data collected. According to Cohn (2008) volunteers are paired with a scientist or staff member to collect the same data, allowing a comparison of accuracy.

Methods

Bowman Bay and Cornet Bay

Plant morphology and density differed significantly between each zone at both Bowman Bay and Cornet Bay leading to the use of different monitoring methods. In Zone 2 at Bowman Bay and Phase 1 and 2 of Cornet Bay, plantings are comprised of rhizomatous grasses and forbs representing a beach grass community and were subsampled for plant cover using a 4 ft. x 4 ft. quadrat. In Zone 3 at Bowman Bay and Phase 1 and 2 at Cornet Bay, installed vegetation represents the backshore shrub zone and was evaluated individually with a survivorship rating and a measure of height. These zones were also sub-sampled with a 4ft. x 4 ft. quadrat. In Zone 3 at Bowman Bay and Zone 4 at Cornet Bay Phase 1 and 2, installed vegetation represents the shoreline fringe forest zone and was again evaluated using a survivorship rating and subsampled with a 4ft. x 4ft. quadrat. Resources used for plant identification include: *Plants of the Pacific Northwest* by Pojar and Mckinnion, *Wildlfowers of the Pacific Northwest* by Mark Turner and Phyllis Gustafson and *Weeds of the West*, by Tom Whitson.

Plant Cover

In Zones 2 and 3 at Bowman Bay and Phase 1 and 2 of Cornet Bay, an assessment of coverage was utilized by running transects through the planting area and parallel to the shoreline. Transects were located every 4 feet until the end of the planting area was reached. Along each transect, a 4 ft. x 4 ft. quadrat was placed at intervals of 16 ft., creating a 25% sample size. For each quadrat sampled, the surveyors identified all plants and determined if they were live or dead. The number of live plants determined the density of native plants in each quadrat.

Plant Cover was estimated for each quadrat in three categories: native vegetation, non-native vegetation, and bare ground. Native vegetation was defined by any plant that would occur and grow naturally in the area without the need of human intervention. Non-native vegetation was deemed any plant that is introduced, or known as an invasive species. Plant cover was estimated by counting vertices within the quadrat grid for each cover class. Each quadrat was comprised of 121 vertices created by crossing 11 lines of string spaced 4'' apart by 11 perpendicular lines of the same spacing. At each vertex, the cover class was recorded.

For a complete protocol on how to measure plant cover and survivorship in the field including a materials list and data sheets see Appendix 10-14.

Figure 5: Example of 4 ft. spacing of transects

Plant Density

To determine plant density, the number of native plants in each quadrat was counted. Thresholds for plant density were determined by Skagit Fisheries Enhancement Group and differed at each site. At Bowman Bay, 7 native plants per quadrat were considered the original density of installed plants while in both phases at Cornet Bay, 3 native plants per quadrat were considered the original density of installed plants.

Survivorship Rating

In Zone 3 at Bowman Bay and Zone 3 and 4 at Cornet Bay, all installed and recruited plant species were assessed by height taken from the root crown to the apical bud using a stadia rod. An evaluation of survivorship was also utilized to evaluate the health and vigor of each plant (Figure 5) (Figure 6).

Figure 6: Survivorship rating and corresponding description.

Survivorship Rating	Description
1	Dead or nearly dead
2	Live plant with dead portions and/or signs of stress
3	Signs of new vegetative growth without reproduction
4	Poor reproduction (few and poorly developed flowers/fruit)
5	Healthy reproduction (many well-developed flowers/fruit)

Figure 7: Volunteer's assessing height and Survivorship of *Lathyrus japonicus* at Bowman Bay

Natural Recruitment

The criteria used for determining natural recruitment were based on species identity, proximity to other installed plants, and original planted species list. The source of naturally recruited plants could originate from seed rain of installed plants or from existing adjacent vegetation. It could also originate from rhizomatous plant growth or seed blown in from adjacent areas. For example, *Gaultheria shallon* plants were considered naturally recruited if vegetation was more than a foot away and distinct from the parent plant.

Data Analysis

Plant Cover

Plant cover for Zones 2 and 3 at Bowman Bay and Phase 1 and 2 at Cornet Bay was determined by summing the vertices of each cover class for all quadrats within each zone. This was then converted to a percent.

Plant Density

Plant density thresholds for each project varied due to different performance thresholds. At Bowman Bay, original plant density was deemed 7 native plants per quadrat, which is an estimation of plant density per quadrat at the time of original installation. At Cornet Bay, plant density was estimated at 3 native plants per quadrat. Plant density was determined by counting the number of native plants within each quadrat. A percentage of well-stocked quadrats was found by summing the total number of quadrats that met minimum requirements for plant density per site and dividing that number by the total number of quadrats sampled.

Survivorship

Survival for Zone 4 at Bowman Bay and Zone 4 of Phase 1 and 2 at Cornet Bay was calculated by dividing the number of live plants (i.e. plants with health ratings from 2 to 4) by the number of plants installed in Zone 4 during the project.

Distribution of Plant Species

Plant species distribution was quantified using data gathered fro plant cover. At Bowman Bay, the number of live plant species present across all quadrats for Zone 2 was summed then converted to a percent by dividing the number of live plants by the total number of plants present. At Cornet Bay, the number of live plant species present across all quadrats for Zone 2 and 3 for Phase 1 and 2 were summed and then converted to a percent by dividing the number of live plants by the total number of plants present.

Results

Bowman Bay

Zone 2

A total of 45 quadrats were sampled in Zone 2 for plant cover and density. *Leymus mollis* was the most widely distributed plant species in Zone 1 at 78.40% (Figure 8) while the majority of groundcover consisted of bare ground at 93% (Figure 9). Stocking was poor in Zone 2. Of 45 quadrats, 33 were under-stocked with 6 or fewer native plants per quadrat. 11 quadrats were well stocked at 7-21 native plants per quadrat; therefore no quadrats had 21 or more native plants (Figure 10).

Figure 8: Distribution of plant species in Zone 2 at Bowman Bay

Common name	**Latin name**	**No. Live**	**% of Total**
Dune Wild Rye	*Leymus mollis*	127	78.40%
Pacific Silverweed	*Argentina egedii*	35	21.60%
Total		**162**	**100.00%**

Figure 9: Photo illustration and Plant Cover in Zone 2 at Bowman Bay

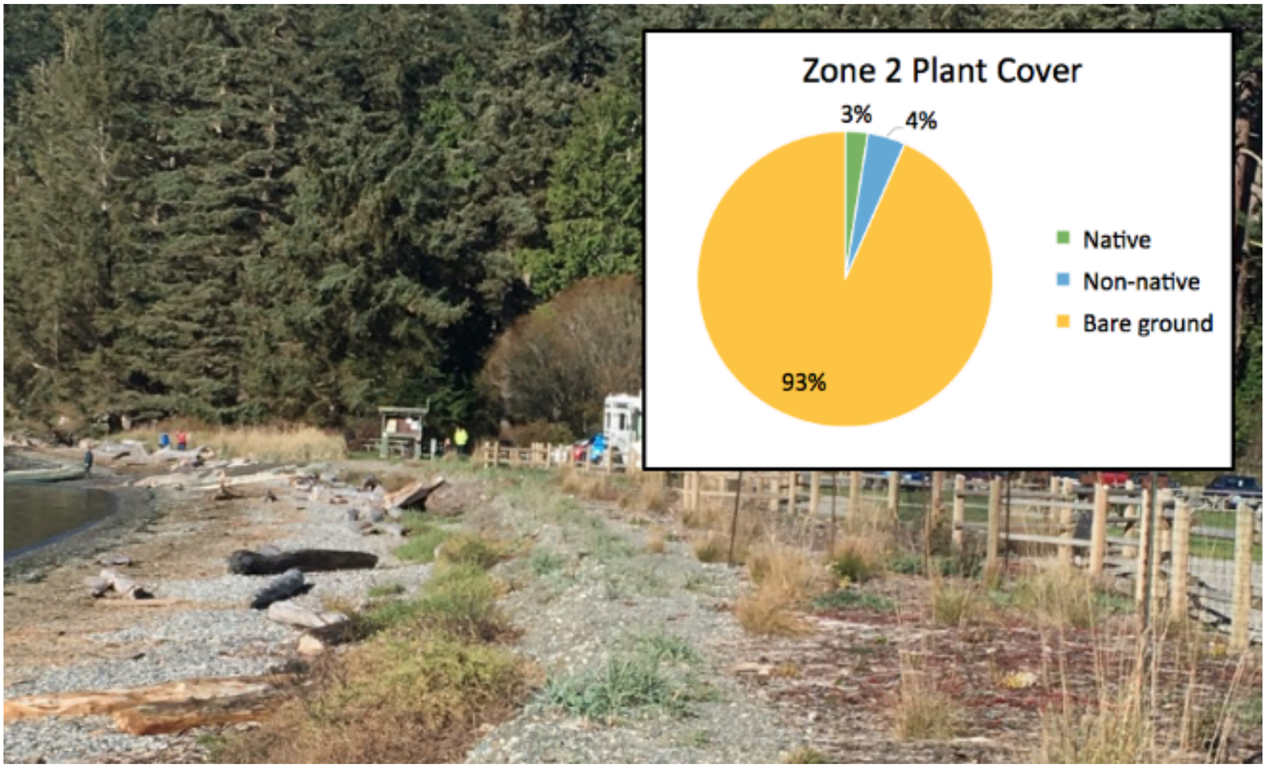
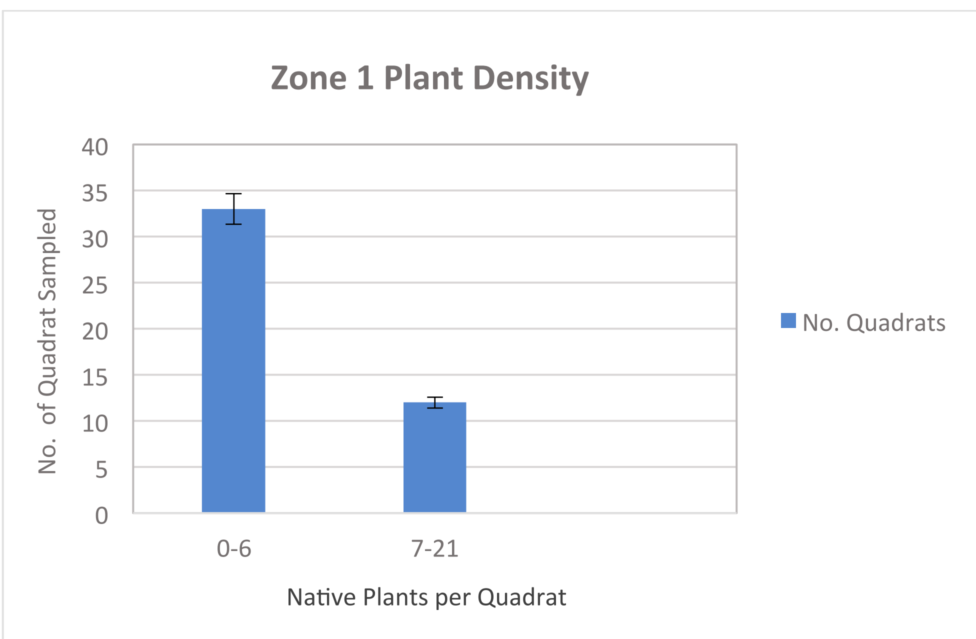


Figure 10: Zone 1 Stocking at Bowman Bay



Zone 3

A total of 76 quadrats were sampled for plant cover in Zone 3. The survival of plants in Zone 3 one full year after planting was 65% (Figure 11). Note that 98 plants had a survivorship rating of 1 (plants which are dead or nearly dead). This could represent *Sambucus racemosa*, *Lupinus littoralis*, *Malus fusca*, *Polystichum munitum* or *Amelanchier alniflora* which all had survival rates of 0% in year one. The plant species with the highest survival rates were: *Gaultheria shallon*, *Lathyrus japonicus, Ribes sanguineum*, *Rosa nutkana* and *Spirea douglasii.* Additionally, 398 plants had a health rating of 2 (Live plants with dead portions and/or signs of stress) (Figure 11). Several species, such as *Lathyrus japonicus* and *Rosa nutkana*, both of which spread easily due to rhizomatous reproductive strategies, are present in substantially higher numbers than were originally installed. Other native plant species, such as *Grindelia integrifolia*, *Alnus rubra* and native conifer species are actively colonizing the area.

Figure 11: Plant survivorship in Zone 3 at Bowman Bay

		S. Rating									
Common Name	Latin Name	*1*	2	3	4	5	Total	Installed Originally	Live 2017	% Surv.	Average of Height (ft)
Pearly Everlasting	*Anaphalis margaritacea*	5	4	2			8	150	6	4%	0.3
Serviceberry	*Amelanchier alnifolia*						0	2	0	0%	0.0
Tufted hairgrass	*Deschampsia cespitosa*		1	3		3		80	7	9%	0.2
Coastal strawberry	*Fragaria chiloensis*		16	1	2	2	21	150	21	14%	0.1
Salal	*Gaultheria shallon*	2	106	53	7		168	169	168	99%	0.3
Oceanspray	*Holodiscus discolor*	1	1				2	4	1	25%	2.1
Beach Pea	*Lathyrus japonicus*		107	23	21	90	241	50	241	482%	0.3
Tall oregon grape	*Berberis aquafolium*	5	18	4			27	55	22	40%	0.4
Pacific crabapple	*Malus fusca*	2					2	2	0	0%	5.5
Dull oregon grape	*Berberis nervosa*		1	1	1		3	80	3	4%	0.4
Sword Fern	*Polystichum munitum*	2					2	50	0	0%	0.2
Red Flowering Currant	*Ribes sanguineum*	9	11	2			22	8	13	163%	2.0
Nootka rose	*Rosa nutkana*	5	54	16			75	58	70	121%	1.6
Hardhack	*Spirea douglasii*	20	50	2	1		73	55	53	96%	1.6
Snowberry	*Symphoricarpos albus*	6	26	6			38	58	32	55%	1.0
Red elderberry	*Sambucus racemosa*						0	2	0	0%	0.0
Beach lupine	*Lupinus littoralis*						0	6	0	0%	0.0
Unknown		41	3				44	n/a	3	n/a	n/a
Total		**98**	**398**	**113**	**32**	**95**	**726**	**979**	**640**	**65%**	**0.9**

Figure 11: Plant survivorship in Zone 3 at Bowman Bay

Stocking was moderate in Zones 2 and 3. Of 75 total quadrats sampled, 12 quadrats were under-stocked with 6 or fewer native plants per quadrat. 47 quadrats had 7-21 native plants per quadrat and 16 had 22-130 native plants per quadrat (Figure 12). Therefore, the predominate cover class in Zone 2 and 3 is bare ground (Figure 13). Note that non-native plant cover was measured at 0%.

Figure 12: Plant density in Zone 2 and 3 at Bowman Bay

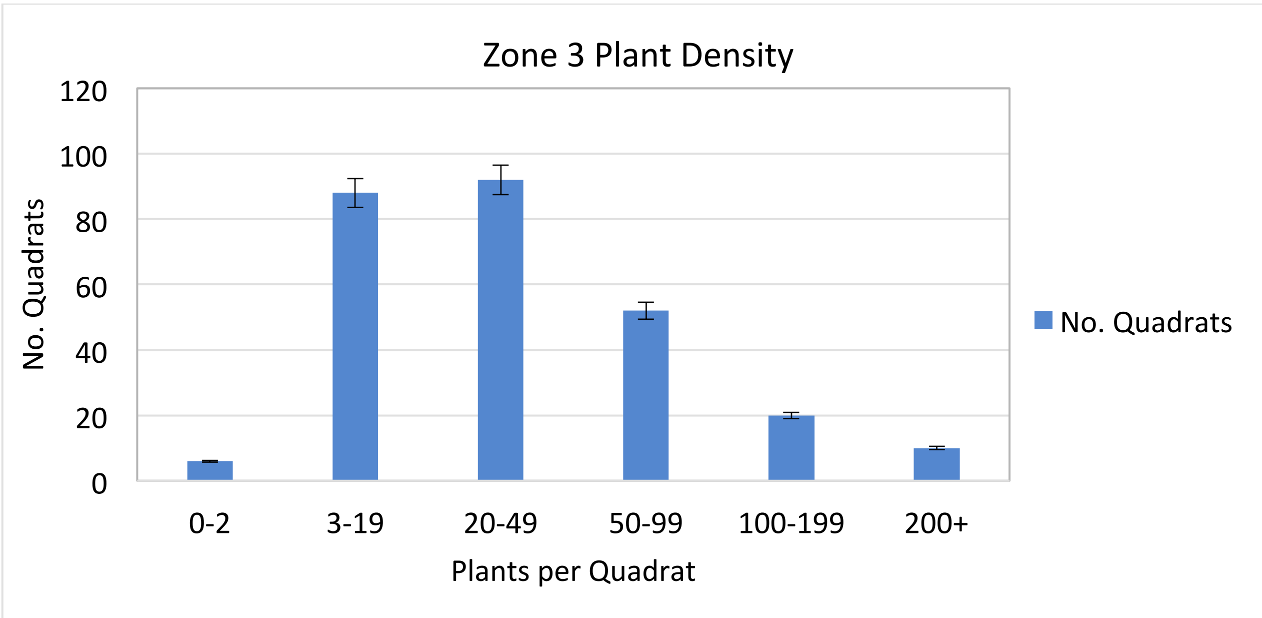
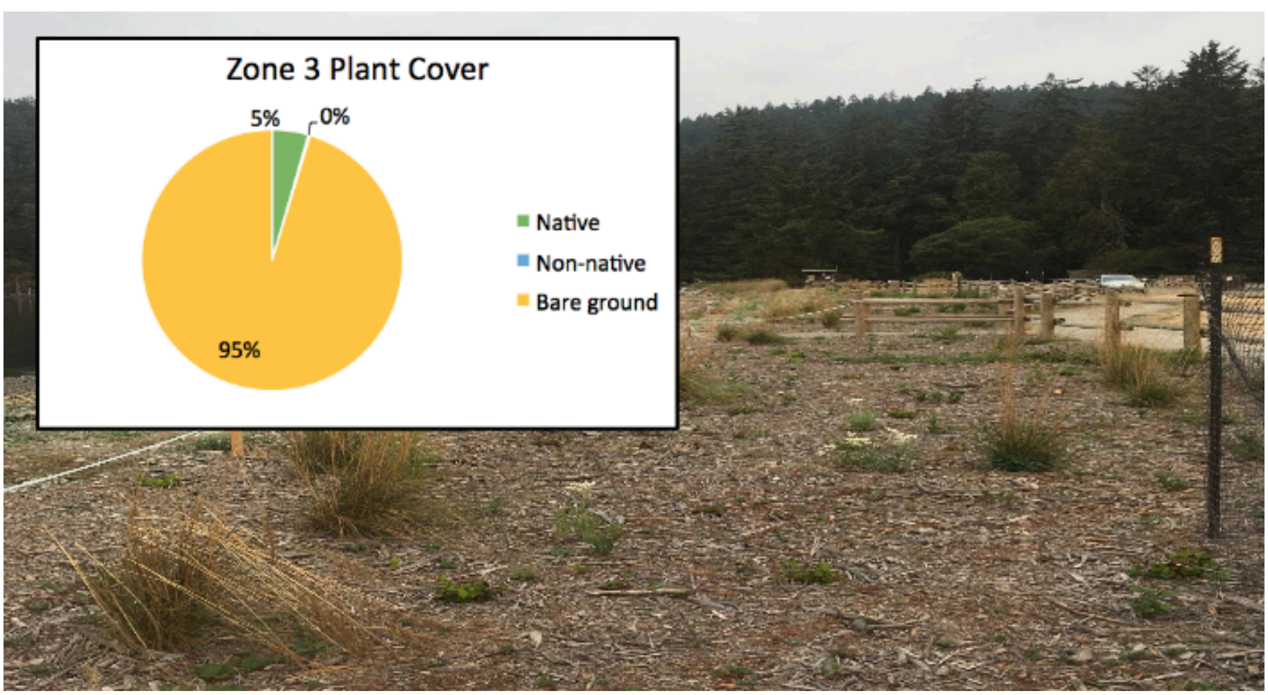


Figure 13: Plant cover in Zone 3 at Bowman Bay



A total of 81 plants were measured as naturally recruited in Zone 2 (Figure 14). This included many conifer and *Alnus rubra* seedlings in addition to *Grindelia integrifolia* (Figure 15).

Figure 14: Natural recruitment in Zone 2 at Bowman Bay

		S. Rating						
Common Name	**Latin Name**	***1***	**2**	**3**	**4**	**5**	**Total**	**Average of Height (ft)**
Alder	*Alnus rubra*	1	31	2		3	36	0.20
Hookers willow	*Salix hookeriana*			1	1		2	2.40
Western red cedar	*Thuja plicata*		1				1	5.50
Gumweed	*Grindelia integrifolia*	1		2			3	0.40
Conifer Seedling				37	1	1	39	0.10
Total		**2**	**32**	**42**	**2**	**4**	**81**	**1.72**

Figure 15: Recruited *Grindelia integrifolia*

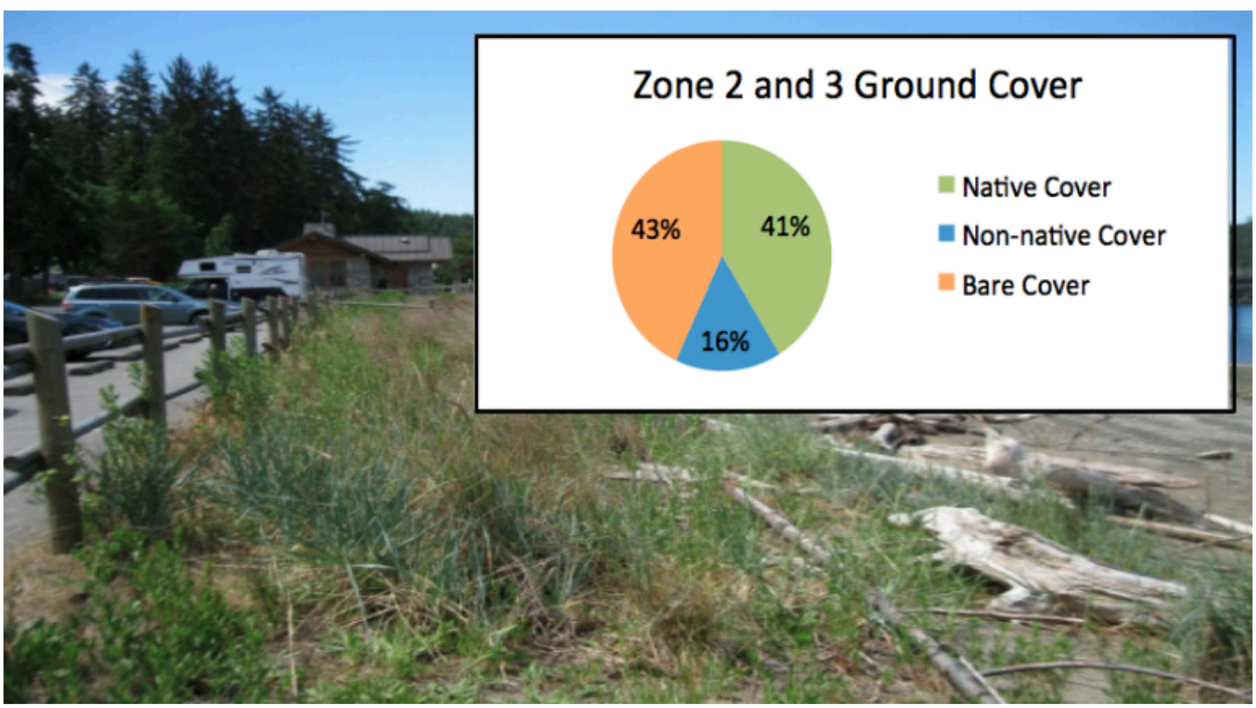
Cornet Bay

Phase 1

Zone 2 and 3

268 quadrats were sampled for coverage and stocking in Zones 2 and 3 of Phase 1. A total of 4,850 plants were originally installed in the 0.63 acre area, at a spacing of approximately 2 foot centers. There is still a significant percentage of bare ground cover at 43% (Figure 16). Native vegetation covers 41% of the area and non-native ground cover is at 16%. Native cover slightly decreased from the previous year (from 51% to 41%).

Figure 16: Plant cover in Zones 2 and 3 at Cornet Bay Phase 1



The most widely distributed native plant species was *Grindelia integrifolia*, *Argentina egedii* and *Equisteum arvense* followed by *Scirpus americanus, Leymus mollis* and *Carex obnupta* (Figure 17). Non-native species that are actively colonizing the site include European pasture grasses and species of clover.

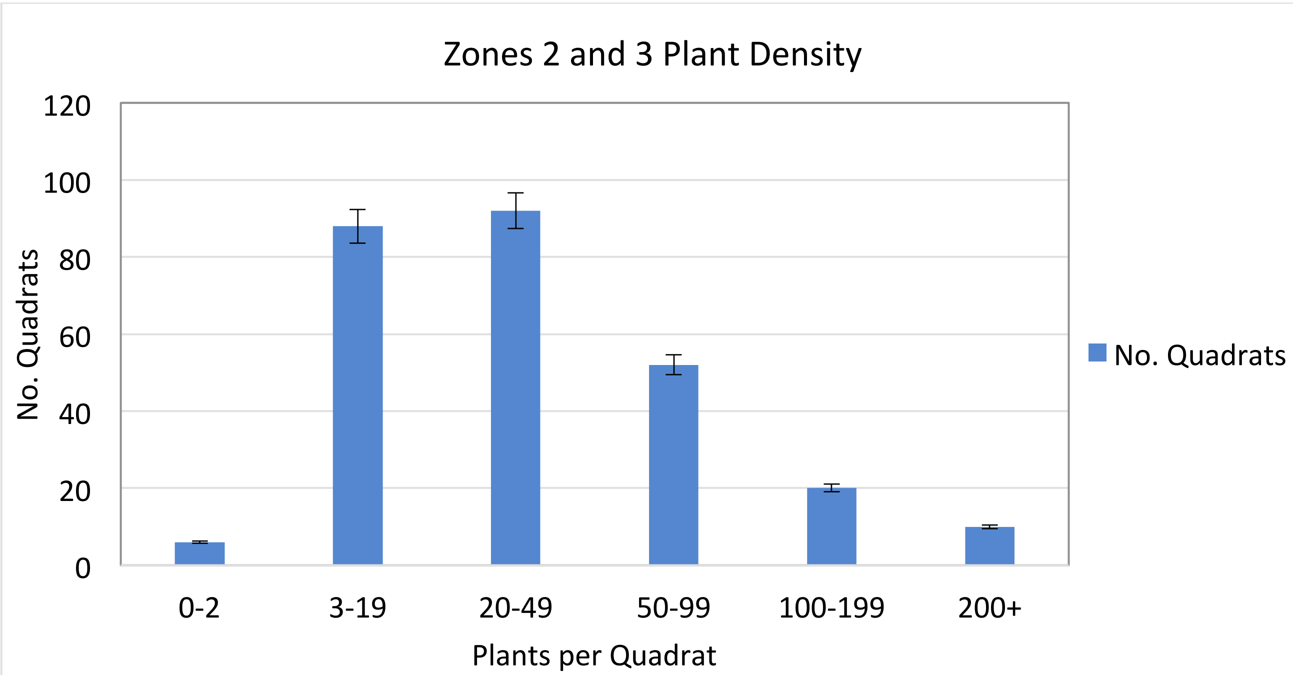
Figure 17: Plant distribution in Phase 1, Zones 2 and 3 at Cornet Bay

Common Name	**Latin Name**	**No. Live**	**%**
Red alder	*Alnus Rubra*	491	2.94%
Aster spp.	Asteraceae spp.	18	0.11%
Baltic rush	*Juncus balticus*	156	0.93%
Beach pea	*Lathyrus japonicas*	1	0.01%
Big leaf maple	*Acer macrophyllum*	1	0.01%
Black medic	*Medicago lupulina*	21	0.13%
Bracken fern	*Pteridium aquilinum*	1	0.01%
Clover spp.	*Trifolium* spp.	732	4.38%
Coastal strawberry	*Fragara chiloensis*	4	0.02%
Common horsetail	*Equisetum arvense*	829	4.96%
Conifer Seedling	N/A	211	1.26%
Cow parsnip	*Heracleum lanatum*	7	0.04%
Crabapple	*Malus fusca*	5	0.03%
Dandelion	*Taraxacum officinale*	234	1.40%
Douglas Fir	*Pseudotsuga menziesii*	13	0.08%
Dovefoot geranium	*Geranium molle*	14	0.08%
Dull oregon grape	*Berberis nervosa*	2	0.01%
Dune wild rye	*Leymus mollis*	628	3.75%
English plantain	*Plantago lanceolata*	324	1.94%
Erect knotweed	*Polygonum erectum*	17	0.10%
Glasswort	*Salicornia virginica*	5	0.03%
Grand fir	*Abies grandis*	1	0.01%
Gumweed	*Grindelia integrifolia*	7275	43.50%
Hairy Willowherb	*Epilobium minutum*	309	1.85%
Himalayan blackbery	*Rubus armeniacus*	30	0.18%
Hookers willow	*Salix hookeriana*	2	0.01%
Lambsquarter	*Chenopodium album*	49	0.29%
Lygnby's Sedge	*Carex lyngbyei*	7	0.04%
Marigold	*Tagetes* spp.	1	0.01%
Nootka rose	*Rosa nutkana*	45	0.27%

Oceanspray	*Holodiscus discolor*	14	0.08%
Osoberry	*Oemleria cerasiformis*	7	0.04%
Pacific Silverweed	*Argentina egedii*	1651	9.87%
Pasture Grass	N/A	1599	9.56%
Pearly Everlasting	*Anaphalis margaritacea*	248	1.48%
Pineapple Weed	*Matricaria discoidea*	8	0.05%
Queen anne's lace	*Daucus carota*	10	0.06%
Salal	*Gaultheria shallon*	56	0.33%
Salmonberry	*Rubus spectabilis*	21	0.13%
Sea plantain	*Plantago maritima*	13	0.08%
Sea thrift	*Armeria maritime*	9	0.05%
Shore Pine	*Pinus contorta*	3	0.02%
Sitka Spruce	*Picea sitchensis*	215	1.29%
Slough sedge	*Carex obnupta*	482	2.88%
Snowberry	*Symphoricarpos albus*	47	0.28%
Spotted catsear	*Hypochaeris radicata*	29	0.17%
Sweetgale	*Myrica gale*	1	0.01%
Sword Fern	*Polystichum munitum*	2	0.01%
Tall Oregon Grape	*Berberis aquafolium*	11	0.07%
Thimbleberry	*Rubus parviflorus*	3	0.02%
Thistle spp.	*Cirsium spp.*	32	0.19%
Three square sedge	*Scirpus americanus*	681	4.07%
Trailing Blackberry	*Rubus ursinus*	21	0.13%
Tufted Hairgrass	*Deschampsia cespitosa*	54	0.32%
Twinberry	*Lonicera involucrate*	1	0.01%
Vetch spp.	*Vicia* spp.	25	0.15%
Western Hemlock	*Tsuga heterophylla*	2	0.01%
Western Red Cedar	*Thuja plicata*	13	0.08%
Wild Lettuce	*Lactuca virosa*	4	0.02%
Willow	*Salix spp.*	30	0.18%
Yarrow	*Achillea millefolium*	1	0.01%
Total		**16,726**	**100.00%**

Zones 2 and 3 are well stocked. 98% of quadrats sampled had 3 or more native plants per quadrat. 6 quadrats were poorly stocked with 0-2 native plants per quadrat however; the majority of sampled quadrats had 20-49 native plants or more per quadrat (Figure 18).

Figure 18: Native Plant Density in Zones 2 and 3 of Phase 1 at Cornet Bay



Zone 4

In 2017, Zone 4 had an estimated survival rate of 72% (Figure 19). *Ribes sanguineum* and *Picea sitchensis* were the most abundant plant species with survival rates of 154% and 115%, respectively. The most frequent health rating was "3", (exhibiting poor reproduction characterized by few and poorly developed flowers and/or fruit) followed by a health rating of "2" (live plant with dead portions and/or signs of stress). This signifies that many plants species are struggling to establish on site. Approximately 54 species were assigned a health rating of "1" (Dead or nearly dead). Therefore the "unknown" species listed were unidentifiable

Figure 19: Survivorship rating of planted species in Zone 4 Phase 1 of Cornet Bay

		S. Rating									
Common Name	**Plant Code**	***1***	**2**	**3**	**4**	**5**	**Total**	**Installed Originally**	**Live 2017**	**% Surv.**	**Average of Height (ft)**
acific madrone	*Arbutus menziesii*			1			1	2	1	50%	1.10
alal	*Gaultheria shallon*	2	11	46	132	36	227	420	225	54%	0.67
ceanspray	*Holodiscus discolor*	1	29	58	1	1	90	100	89	89%	1.81
lack Twinberry	*Lonicera involucrata*		11	18	2	2	33	50	33	66%	3.69
all oregon grape	*Berberis aquifolium*	3	12	69	5	4	93	115	90	78%	1.98
acific crabapple	*Malus fusca*		21	4			25	37	25	68%	1.45
ow oregon Grape	*Berberis nervosa*		3	8		1	12	50	12	24%	0.83
soberry	*Oemleria cerasiformis*	6	19	6			31	60	25	42%	1.84
itka spruce	*Picea sitchensis*		2	61	3		66	57	66	116%	4.52
word fern	*Polystichum munitum*	1	8	2			11	50	10	20%	0.56
ed Flowering urrant	*Ribes sanguineum*	3	12	23	6	4	48	30	45	150%	2.64
ootka rose	*Rosa nutkana*	4	47	99	15	9	174	200	170	85%	1.30
almonberry	*Rubus spectablis*		5	32		1	38	50	38	76%	1.71
Villow	*Salix spp.*		1	19			20	70	21	30%	4.90
nowberry	*Symphoricarpos albus*	9	46	144	75	20	294	300	285	95%	2.02
Vestern red cedar	*Thuja plicata*	2	6	29	1		38	57	36	63%	5.41
nknown		26	11	2			39	N/A	13	n/a	n/a
otal		**57**	**244**	**621**	**240**	**78**	**1240**	**1648**	**1184**	**72%**	**2.3**

1,443 plants are recorded as naturally recruited (Figure 20). This includes an abundance of *Picea sitchensis*, *Symphoricarpus albus*, *Gaultheria shallon* and *Rosa nutkana*, which were originally installed on site. Recruited species which were not originally planted but which bring diversity to the site are *Myrica gale*, *Ribes lacustre* and *Rubus ursinus*.

Figure 20: Recruited plant species in Zone 4 of Phase 1 at Cornet Bay

Common Name	Latin Name	Total
Grand fir	*Abies grandis*	2
Red alder	*Alnus rubra*	109
Kinnick-kinnick	*Arctostaphylos uva-ursi*	1
Salal	*Gaultheria shallon*	303
Oceanspray	*Holodiscus discolor*	73
English holly	*Illex aquifollium*	1
Pacific crabapple	*Malus fusca*	13
Tall oregon grape	*Berberis aquifolium*	48
Sweet Gale	*Myrica gale*	3
Shore pine	*Pinus contorta*	8
Sitka spruce	*Picea sitchensis*	500
Douglas fir	*Pseudotsuga menziesii*	29
Black gooseberry	*Ribes lacustre*	7
Red flowering currant	*Ribes sanguineum*	3
Nootka rose	*Rosa nutkana*	145
Salmonberry	*Rubus spectabilis*	9
Trailing blackberry	*Rubus ursinus*	7
Hookers willow	*Salix hookeriana*	3
Pacific willow	*Salix lucida*	2
Hardhack	*Spirea douglasii*	6
Snowberry	*Symphoricarpos albus*	152
Western red cedar	*Thuja plicata*	12
Western hemlock	*Tsuga heterophylla*	7
Total		**1,443**

Phase 2

Zone 2 and 3

A total of 126 quadrats were sampled in Zones 2 and 3 of Phase 2. Native ground cover was measured at 5% (Figure 21). Bare ground was the predominant cover class in Zones 2 and 3 at approximately 93%. *Alnus rubra* and conifer seedling plant recruitments were the most abundant species sampled in this cover class at 23% and 26%, respectively (Figure 22). However, the probability of all recruited seedlings surviving the harsh conditions of the site is unlikely. Non-native European pasture grasses were the most abundant species within Zones 2 and 3, representing 11% of the plants counted.

Figure 21: Plant Cover in Zone 2 and 3 at Cornet Bay Phase 2

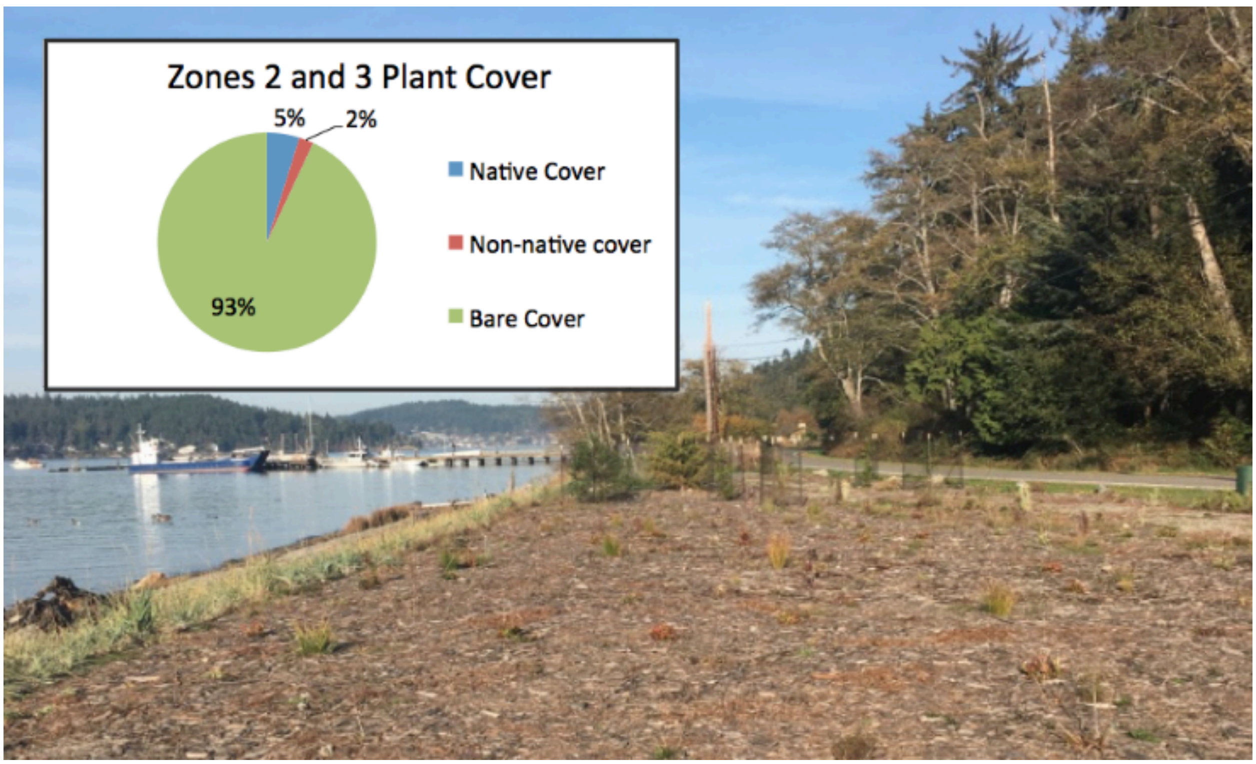


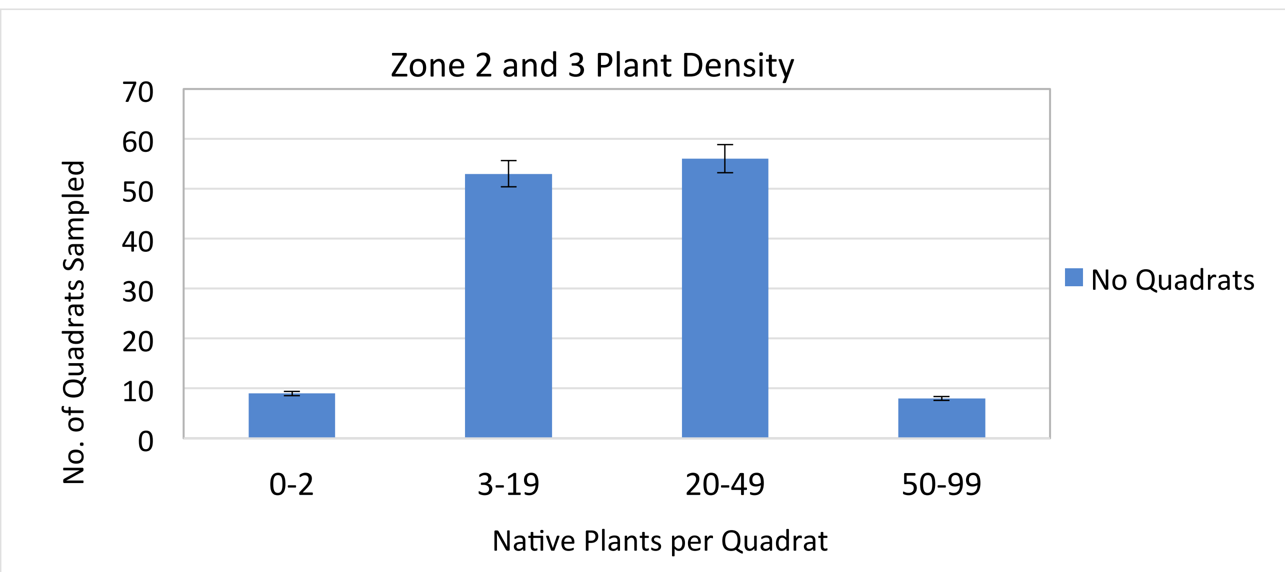
Figure 22: Plant Distribution in Zones 2 and 3 in Phase 2 at Cornet Bay

Common name	Latin Name	No. Live	%
Aster	*Asteraceae spp.*	2	0.04%
Baltic rush	*Juncus balticus*	1	0.02%
Beach pea	*Lathyrus japonicus*	1	0.02%
Black medic	*Medicago lupulina*	92	1.98%
Himalaya blkberry	*Rubus armeniacus*	6	0.13%
Cow parsnip	*Heracleum lanatum*	1	0.02%
Clover	Cirsium spp.	336	7.24%
Coastal strawberry	*Fagaria chiloensis*	9	0.19%
Common groundsel	*Senecio triangularis*	2	0.04%
Conifer seedling	N/A	1235	26.61%
Crabapple	*Malus fusca*	3	0.06%
Dandelion	*Taraxacum officinale*	50	1.08%
Dune wild rye	*Leymus mollis*	223	4.80%
Erect knotweed	*Polygonum erectum*	122	2.63%
Spotted catsear	*Hypochaeris radicata*	22	0.47%
Willow spp.	Salix spp.	1	0.02%
Horsetail	*Equisetum arvense*	186	4.01%
Lambsquarters	*Chenpodium album*	25	0.54%
Nootka rose	*Rosa nutkana*	4	0.09%
Oceanspray	*Holodiscus discolor*	8	0.17%
Pacific silverweed	*Argentina egedii*	32	0.69%
Pasture grass	N/A	556	11.98%
Pearly everlasting	*Anaphalis margaritacea*	1	0.02%
Plantain	*Plantago lanceolata*	177	3.81%
Queen Anne's lace	*Daucus carota*	1	0.02%
Red Alder	*Alnus rubra*	1,090	23.49%
Red flowering currant	*Ribes sanguineum*	3	0.06%
Salal	*Gaultheria shallon*	33	0.71%
Salmonberry	*Rubus spectabilis*	6	0.13%
Sea plantain	*Plantago maritima*	21	0.45%
Sea rocket	*Cakile maritima*	3	0.06%
Self heal	*Prunella spp.*	4	0.09%
Sheep sorrel	*Rumex acetosella*	142	3.06%
Sitka spruce	*Picea sitchensis*	2	0.04%
Snowberry	*Symphoricarpos albus*	13	0.28%
Thistle	*Cirsium* spp.	158	3.40%
Tall oregon grape	*Berberis aquafolium*	7	0.15%
Vetch	*Vicia* spp.	7	0.15%

Western red cedar	*Thuja plicata*	1	0.02%
Wild lettuce	*Lactuca virosa*	20	0.43%
Willow herb	*Epilobium ciliatum*	35	0.75%
Total		**4641**	**100.00%**

Plant density at the time of plant installation was estimated to be 3 native plants per quadrat by SFEG. Therefore, quadrat samples with 3 or more plants were considered well stocked at an 80% survival rate. Zones 2 and 3 of Phase 2 are faring well, with only 3 of 23 quadrats under- stocked (i.e. 0-2 plants per quadrat) (Figure 23). 14 quadrats are well-stocked with 3-19 plants per quadrat and 5 have more than 20 plants per quadrat. 93% of all sampled quadrats were above the 80% threshold for plant density.

Figure 23: Plant density in Zones 2 and 3 at Cornet Bay Phase 2



Zone 4

Plant survival in Zone 4 of Phase 2 was over 100% (Figure 24 and 25). This is an increase from 74% the previous year. However, note that 196 plants were given a mortality rating of 2 (live plant with dead portions and/or signs of stress). This signifies that though overall plant survival is high many plants are struggling. Willow species had the poorest survival rate at 14%, however this is an increase from 0% the previous year. In contrast, *Gaultheria shallon* is the most abundant plant species with a survival rate of over 100%. This signifies this species' ability to actively colonize the site with rhizomes, producing plant recruitments. A total of 35 plants were recorded as naturally recruited (Figure 26) including *Ribes lacustre* and *Rubus ursinus*. Additionally, all *Alnus rubra* plant recruitments were seedlings.

Figure 24: Mortality rating for Zone 4 of Phase 2 at Cornet Bay

		M. Rating									
Common Name	***Plant Code***	***1***	**2**	**3**	**4**	**5**	**Total**	**Installed Originally**	**Live 2017**	**% Surv.**	**Average of Height (ft)**
Salal	*Gaultheria shallon*		4	27	46	1	78	50	78	156.0%	0.6
Oceanspray	*Holodiscus discolor*	3	29	8			40	30	27	90.0%	1.6
Tall oregon grape	*Berberis aquafolium*	1	38	15	3	3	60	30	29	96.7%	1.0
Osoberry	*Oemleria cerasiformis*	3	18	2			23	0	20	n/a	2.5
Sitka spruce	*Picea sitchensis*		6				6	5	6	120.0%	3.8
Douglas fir	*Pseudotsuga menziesii*		4				4	5	4	80.0%	5.0
Red flowering currant	*Ribes Sanguineum*		14	4			18	12	18	150.0%	2.0
Nootka rose	*Rosa Nutkana*		27	27	2		56	43	56	130.2%	1.6
Salmonberry	*Rubus spectabilis*	4	17	5			26	30	22	73.3%	1.1
Willow spp.	*Salix spp.*			7			7	50	7	14.0%	2.1
Snowberry	*Symphoricarpos albus*		35	23	3		61	30	61	203.3%	1.5
Western red cedar	*Thuja plicata*		2	2			4	5	5	100.0%	4.7
Unknown		5	2	1			8	n/a	3	n/a	2.0
Total		**16**	**196**	**123**	**54**	**4**	**5**	**290**	**336**	**115.9%**	**2.28**

Figure 25: Photo of Zone 2, 3 and 4 Phase 2 at Cornet Bay

Figure 26: Natural recruitment in Zone 4, Phase 2 at Cornet

Common Name	Latin Name	Total
Red alder	*Alnus rubra*	3
Salal	*Gaultheria shallon*	2
Sitka Spruce	*Picea sitchensis*	1
Nootka rose	*Rosa nutkana*	1
Blackcap raspberry	*Ribes lacustre*	1
Salmonberry	*Rubus spectablis*	3
Trailing Blackberry	*Rubus ursinus*	4
Snowberry	*Symphoricarpos albus*	5
Total		**35**

Discussion

Bowman Bay

Plant Cover in Zones 1 and 2 in terms of native species is poor. The majority of groundcover is bare ground (Figure 9 and 13). However these results are not surprising considering the age of the restoration project. Plant establishment and an increase in aerial cover take time. This is reinforced by the literature on the subject, which indicates that plant establishment rates do increase through time (Scotton 2016).

In the nearshore environment, poor establishment and thus increased numbers of plant mortality is most likely due to the many challenges found on site such as high water infiltration rates due to sandy soils, pedestrian traffic which leads to soil compaction and plant trampling as well as erosive processes. Though native plant cover is low, this is on par with restoration trajectories in terms of the ability of native species to increase establishment rates over time (Pywell 2007).

Lathyrus japonicas, *Gaultheria shallon* and *Rosa nutkana* were measured at higher amounts than installed numbers, signifying that these plant species are reproducing and colonizing the site. This is consistent with studies, which indicate that plant species diversity does initially decrease in years 2-5 but recovers rapidly in years 5-15 (Nilsson *et al.* 2016).

Plant density (Figure 10 and 12) in the beach grass community is low signifying that plants are still struggling to become established. This is the first full year since plant installation and due to the harsh conditions found on-site; plant mortality in this area is palpable. Yet as compared to last year, *Leymus mollis* and *Argentina egedii* individuals in Zone 1 (Figure 8) are increasing, from 138 total live plants in Zone 1 the previous year to 162 plants in 2017. This is considered to be an upward trend, partly due to exclusionary fencing installed on an ephemeral trail, which is most likely discouraging park visitors from trampling vegetation.

Cornet Bay

Phase 1

Browsing by deer continues to be a problem aesthetically in Zone 4, however this doesn't seem to be effecting overall survival. Deer exclusion fencing around individual coniferous trees has been effective in deterring browsing over the last four years. The purpose of deer exclusion fencing was to minimize foliage loss, therefore increasing the probability of tree survival. In 2017, coniferous trees were being outcompeted by plant recruits, *Alnus rubra* and *Salix* spp., within the exclusionary fencing.

Overall the majority of plants sampled are exhibiting a healthy survivorship rating between "3" and "5" as opposed to a poor survivorship rating of "1" and "2" (Figure 16) (see survivorship rating) (Figure 5). This is most likely due to the age of the restoration project and the fact that plants are establishing themselves and actively recruiting the site (Figure 17).

Native plant cover has decreased this year by 10% (Figure 18). This may be due to grazing pressure from deer or trampling from park visitors, both of which would have impacted aerial cover.

The installation of additional plants in Zones 2 and 3 in the winter of 2017 appears to have helped improve plant densities by reducing the number of under-stocked quadrats. Since original plant installation in 2013, plant density has incrementally improved down from about 40% in 2013 to 11% in 2014, 9% in 2015, 7% in 2016 and now 2% in 2017 (Figure 20). Many plants are spreading readily through rhizomatous reproductive strategies and colonizing open spaces.

Yet with age comes pressure from weeds and invasive species, thus an increase in non-native cover is palpable as well. Non-native species cover at Cornet Bay is increasing, from 4% the previous year to 16% in 2017. This is in-line with restoration timelines, as non-native species need continual management to curb overall numbers and density. As the first full year since installation, the seed bank is most likely rebounding from recent on-site work, paired with non-native species in the vicinity senescing and colonizing the site.

Phase 2

Plant survival in Zone 4 is over 100%. The current monitoring year of 2017 represents the first full year since plant installation. However note that 196 plants, the majority of plants sampled, were given a health rating of “1” (Dead or nearly dead) or “2” (Live plant with dead portions or signs of stress) (Figure 22). This signifies that many plants are struggling to become established.

In contrast, natural recruitment for year 1 was measured at 35 native plants (Figure 23). For instance, *Symphoricarpos albus* and *Alnus rubra* are readily colonizing the site, signifying these plant species find the site conditions adequate and are naturally spreading.

Native plant cover is low. The predominate cover class represented is bare ground (Figure 24). This signifies that plants are still struggling to establish on site. This is most likely due to the harsh conditions of the nearshore environment such as soils that do not retain water and anthropogenic impacts such as pedestrian traffic which contribute to soil compaction. Non-native plants species coverage was measured at 2%, which signifies non-native species are presently not an issue in these zones.

Most quadrats are well stocked in Phase 2, which signifies native species are colonizing the site (Figure 26). However these plants are most likely representative of a mixture of native installed and recruited plants (Figure 26).

Citizen Science

The use of volunteers, or citizen scientists, in data collection requires an acknowledgement of the possibility of error. When monitoring installed vegetation, plant identification is of the utmost importance. Therefore communications between volunteers and myself emphasized the importance of asking for help with plant identification including the use of botanical keys if identification was not completely positive. Observations in the field reveal that when volunteers were unsure of a species identity they asked for assistance in identification.

Management Recommendations

Bowman Bay

Zone 1

Replanting should occur in order to increase aerial plant cover and density (Figure 26). Since *Leymus mollis* and *Argentina egedii* individuals were the only vegetation to be installed in this zone replanting should occur with these plant species in addition to *Salicornia virginica.* This is recommended for installation as individuals of *S. virginica* were observed on site during sampling. Non-native, *Cakile maritima,* has naturally recruited the area. This species should be removed and replaced with the native, *Cakile edentula*. Eradicating the non-native species and replacing it with the native species will preserve ecological functions this plant was providing within the system.

Although results signify that non-native plant cover has yet to be an issue on site, this is still an aspect of the project that needs to be addressed. On site maintenance activities to curb overall numbers and density of invasive species and weed populations will become increasingly important going forward.

Zone 2

Replanting should occur in Zone 2 in order to increase the number of native plants present on site and facilitate vegetation filling in (Figure 26). Plants that have naturally recruited should also be installed, as natural recruitment is an indicator that site conditions are well adapted to this species' life history traits. For instance, *Grindelia integrifolia* has naturally recruited on site and shows great promise. Other plants that were originally installed but had relatively low survival rates and are recommended for installation to increase overall numbers and density are *Holodiscus discolor* and *Symphoricarpos albus*. Additionally, *Anaphalis margaritacea* and Fragaria chiloensis should also be replanted. Plants which had survival rates of 0% and should not be replanted include: *Polystichum munitum*, *Malus fusca* and *Amelanchier alnifolia*.

Deer exclusion fencing is still installed on the project site around target coniferous tree species such as *Thuja plicata* and *Picea sitchensis*. Currently, exclusionary fencing is not posing any problems and should remain in place.

SFEG has observed low establishment rates of *Sambucus racemosa* at Bowman Bay in addition to other restoration sites. Therefore this species should be direct seeded and monitored to detect if this method is an adequate strategy for improving establishment. Alternatively, the installation of potted stock may be introduced to Zone 4 after a coniferous canopy has been achieved.

Figure 26: Recommended plants for installation at Bowman Bay (Appendix 6)

Common name	Latin name	Form	Qty.	Zone
Dune wild rye	*Leymus mollis*	Bareoot	200	1
Pickleweed	*Salicornia virginica*	1 gal	100	
Pacific silverweed	*Argentina egedii*	Bareroot	150	
American sea rocket	*Cakile edentula*	1 gal	25	
Coastal strawberry	*Fragaria chiloensis*	Bareroot	50	
Coastal gumweed	*Grindelia integrifolia*	Bareroot	50	2
Oceanspray	*Holodiscus discolor*	Bareroot	25	
Snowberry	*Symphoricarpos albus*	Bareoot	25	
Hardhack	*Spirea douglasii*	Bareroot	25	
Sitka Spruce	*Picea sitchensis*	Bareroot	10	

Cornet Bay

Phase 1

Zone 4

Deer exclusion fencing has been effective in protecting planted coniferous trees; however the *Thuja plicata* individuals located within the deer exclusionary fencing are now being outcompeted by recruited *Alnus rubra* and *Salix* spp. These recruited tree species are now the same height or taller than coniferous trees locate in the exclusionary fencing. However the purpose of planted tree species is to facilitate a canopy. Therefore *Alnus rubra* and *Salix* spp. should be left in place as their fast growing nature will provide a canopy quicker and provide necessary shading for the shade-resistant *Thuja plicata*.

Additional plants to be considered for installation in this zone are *Myrica gale* and *Arbutus menziesii* (Figure 27)*. M. gale* was not originally installed on site and is therefore a naturally recruited species. This signifies it's natural inclination for the site and should be encouraged to grow through the installation of more individuals. Originally, two *A. menziesii* were installed on site, yet only one has survived. Therefore additional plants of this species should be installed as replacements.

Additionally due to an increase in non-native coverage, continued maintenance of the site to reduce invasive species and weed populations will be important in the future. For instance, invasive plant species sampled on the site include *Rubus armeniacus*.

Zone 2 and 3

Native grasses and forbs are flourishing in this area; the most abundant native species *Argentina egedii* and *Grindelia integrifolia* is growing profusely and competing well with weeds. However additional plants species should be replanted to facilitate vegetation filling in (Figure 27). For example, *Leymus mollis* and *Argentina edgeii* are recommended for installation. *Plantago maritima* should also be replanted as it was found growing profusely on site. Personal observations have found a potential association of this plant species with *G. integrifolia*. To promote this association, *P. maritima* should be planted in areas where it is absent underneath *G. integrifolia*. *Ribes lacustre* is a naturally recruited plant species in this zone and shows great promise for the future. Due to it's thorny nature this could be a plant installed near pathways to discourage park visitors from entering vegetated areas. Additionally shrubs which had lower survival rates and should be installed to increase overall plant numbers and density include: *Berberis nervosa* and *Gaultheria shallon*.

Thus far, in this early initial phase, weeds are posing minimal issues though continual monitoring of weeds and invasive species will be increasingly important in the future. SFEG monthly volunteer weeding parties during the growing season will continue to be important to curb overall numbers and density of weeds and invasive species.

Figure 27: Recommended plants for installation in Phase 1 Cornet Bay (Appendix 7)

<table>
<tr><th>Common name</th><th>Latin name</th><th>Form</th><th>Qty.</th><th>Zone</th></tr>
<tr><td>Dune wild rye</td><td>Leymus mollis</td><td>Bareroot</td><td>100</td><td rowspan="2">2</td></tr>
<tr><td>Pacific silverweed</td><td>Argentina egedii</td><td>Bareroot</td><td>100</td></tr>
<tr><td>Sea plantain</td><td>Plantago maritima</td><td>Bareroot</td><td>50</td><td rowspan="2">2-3</td></tr>
<tr><td>Coastal gumweed</td><td>Grindelia integrifolia</td><td>Bareroot</td><td>50</td></tr>
<tr><td>Black gooseberry</td><td>Ribes lacustre</td><td>bareroot</td><td>20</td><td>3</td></tr>
<tr><td>Sweet gale</td><td>Myrica gale</td><td>Bareroot</td><td>5</td><td rowspan="2">4</td></tr>
<tr><td>Pacific madrone</td><td>Arbutus menziesii</td><td>Bareroot</td><td>10</td></tr>
</table>

Phase 2

Zone 4

Though overall mortality in this zone is low, replanting should occur to increase plant cover and density (Figure 28). Plants that exhibited a high survivorship rating and should be replanted include *Gaultheria shallon*, *Ribes sanguineum*, *Rosa nutkana* and *Symphoricarpus albus*. Though weeds and invasive species do not pose a significant issue on-site currently, maintenance activities will be important in the future.

Zones 2 and 3

Recommendations for Zone 2 and 3 include the installation of more plant species in order to meet performance standards for plant cover in the future, which will most likely lead to a decrease in the percentage of bare ground (Figure 28). Plant species that should be considered for replanting include *Leymus mollis* and *Argentina egedii*. Additionally, *Holodiscus discolor*, *Berberis aquifolium* and cuttings of on-site *Salix* spp. should be installed. This list represents plants that are doing well but not naturally recruiting. This indicates these plant species are surviving but need extra individuals to increase in numbers to facilitate natural recruitment.

Figure 28: Recommended plants for installation in Phase 2 Cornet Bay (Appendix 8)

Commone name	**Latin name**	**Form**	**Qty.**	**Zone**
Dune wild rye	*Leymus mollis*	Bareroot	100	2
Pacific silverweed	*Argentina egedii*	Bareroot	100	
Salal	*Gaultheria shallon*	Bareroot	20	4
Red flowering currant	*Ribes sanguineum*	Bareroot	20	
Snowberry	*Symphoricarpos albus*	Bareroot	20	
Oceanspray	*Holodiscus discolor*	Bareroot	20	
Tall oregon grape	*Berberis aquifolium*	Bareroot	20	

Conclusions

This study evaluated each restored area by measuring plant cover, density and survivorship. This research addressed several questions including: 1) Was the restoration effort successful in meeting the goals for native plant species establishment on the site? 2) Is long term monitoring necessary? 3) What recommendations for future Puget Sound nearshore restoration projects can be drawn from data gathered on plant survival and progress at Bowman Bay and Cornet Bay?

Management objectives for plant performance for both Bowman Bay and Cornet Bay were not explicitly stated in a monitoring plan thus no benchmarks for plant performance exist. This absence represents a major failing in ecological restoration projects, as the temptation to skip this step and go about "more important" work such as data collection is great (Elzinga *et al* 1998). However a monitoring plan is critical to long-term implementation of monitoring programs. Well designed monitoring programs which include management objectives can demonstrate that current management techniques are working and provide evidence which supports the continuance of a certain management regime whereas the lack of management objectives makes it impossible to conclude whether the restoration resulted in the desired outcomes (Elzinga *et al* 1998). This also impacts adaptive management strategies because no alternative management solutions can be implemented if an objective was never created.

Despite the lack of clearly stated management objectives for plant performance, monitoring should continue long term. This will aid in the identification and evaluation of plants and their survivorship, which can be used to determine the plant species that need to be re-installed, based on low survivorship. This data can also be used to inform future nearshore restoration projects by assessing the plant species at both Bowman Bay and Cornet Bay that did well, based on overall survivorship and recruitment. These plants could then be prioritized for installation at other restoration projects in the Puget Sound nearshore. Long term monitoring also emphasizes the importance of on site maintenance actions such as weeding and watering throughout the growing season to facilitate plant establishment. This will become increasingly important as each restoration project ages and pressure from non-native species becomes more pronounced. Cornet Bay Phase 2 will be monitored until 2019, while the monitoring for Phase 1 has commenced unless other funding sources can be found.

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Appendix

Appendix 1: Original plant species, form and quantities installed at Bowman Bay

Common Name	Latin Name	Qty.	Zone
Pacific silverweed	*Argentina egedii*	300	2
Dune wild rye	*Leymus mollis*	1200	
Pearly everlasting	*Anaphalis margaritaceae*	150	3
Serviceberry	*Amelanchier Alnifolia*	2	
Tall oregon Grape	*Berberis aquafolium*	55	
Low oregon Grape	*Berberis nervosa*	80	
Sword fern	*Polystichum munitum*	50	
Tufted hairgrass	*Deschampsia cespitosa*	80	
Beach strawberry	*Fragaria chiloensis*	150	
Salal	*Gaultheria shallon*	169	
Oceanspray	*Holodiscus discolor*	4	
Beach pea	*Lathyrus japonicus*	50	
Pacific crabapple	*Malus fusca*	2	
Red flowering currant	*Ribes sanguineum*	8	
Nootka rose	*Rosa nutkana*	58	
Hardhack	*Spirea douglasii*	55	
Snowberry	*Symphoricarpos albus*	58	
Red Elderberry	*Sambucus racemosa*	2	
Total		**2473**	

Appendix 2: Additional plant species, form and quantities installed in 2017 at Bowman bay

Common Name	Latin Name	Form	Qty.	Zone
Pacific silverweed	Argentina egedii	bareroot	200	1
Dune wild rye	Leymus mollis	bareroot	200	
Oceanspray	Holodiscus discolor	1 gal	5	2
Nootka Rose	Rosa nutkana	1 gal	5	
Salal	Gaultheria shallon	1 gal	15	
Pearly everlasting	Anaphalis margaritaceae	pot	20	
Ocean Spray	Holodiscus discolor	1 gal	8	
Hooker's Willow	Salix Hookeriana	Live stake	8	
Total			**461**	

Appendix 3: Original Plant species, form and quantities installed in Phase 1 at Cornet Bay

Common name	Latin name	Form	Qty.	Zone
Dune wild rye	*Leymus mollis*	Bareroot	1,450	2
American Three square	*Scirpus americanus*	Bareroot	420	
Salt grass	Distychlus spicata	Bareroot	400	
Lyngby's sedge	*Carex lyngbyei*	Bareroot	275	
Pacific silverweed	*Argentina egedii*	Bareroot	50	
Baltic rush	*Juncus balticus*	Bareroot	450	3
Soft rush	*Juncus effesus*	Bareroot	450	
American Three square	*Scirpus americanus*	Bareroot	450	
Tufted hairgrass	*Deschmpsia cespitosa*	Bareroot	250	
Pacific silverweed	*Argentina egedii*	Bareroot	150	
Coast gumweed	*Grindelia integrfolia*	1 gal	50	
Sea pink	*Armeria maritima*	1 gal	50	
Sitka spruce	*Picea sitchensis*	5 gal	7	4
Sitka spruce	*Picea sitchensis*	2 gal	50	
Western red cedar	*Thuja plicta*	5 gal	7	
Western red cedar	*Thuja plicta*	2 gal	40	
Pacific crabapple	*Malus fusca*	2 gal	37	
Madrone	*Arbutus menziesii*	1 gal	2	
Red Elderberry	*Sambucus racemosa*	1 gal	51	
Twinberry	*Lonicera involucrata*	1 gal	5	
Salmonberry	*Rubus spectabilis*	1 gal	57	
Scoulers willow	*Salix scouleriana*	1 gal	50	
Pacific crabapple	*Malus fusca*	1 gal	30	
Red flowering currant	*Ribes sanguineum*	1 gal	32	
Nootka rose	*Rosa nutkana*	1 gal	160	
Snowberry	*Symphoricarpus albus*	1 gal	240	
Oceanspray	*Holodiscus discolor*	1 gal	158	
Tall oregon grape	*Berberis aquafolium*	1 gal	116	
Low oregon grape	*Berberis nervosa*	1 gal	50	
Salal	*Gaultheria shallon*	1 gal	480	
Sword fern	*Polystichum munitum*	1 gal	50	
Total			**6,067**	

Appendix 4: Additional plant species, form and quantities installed at Phase 1 of Cornet Bay

Common name	**Latin name**	**Form**	**Qty.**	**Zone**
Dune Wild Rye	*Leymus mollis*	Bareroot	100	2
Pacific silverweed	*Argentina egedii*	Bareroot	100	
Sea Plantain	*Plantago maritima*	Bareroot	100	
Beach pea	*Lathyrus japonicus*	I gal	120	
Coastal strawberry	*Fragaria chiloensis*	Bareroot	20	3
Scouler's willow	*Salix scouleriana*	Livestake	Havested from site	
Tall oregon grape	*Berberis aquafolium*	1 gal	10	
Douglas Fir	*Psedotsuga menziesii*	2 gal	2	4
Total			**422**	

Appendix 5: Original plant species and quantities in Phase 2 at Cornet Bay

Common Name	**Latin name**	**Form**	**Qty.**	**Zone**
Pickleweed	Salicornia virginica	Salvage	20-40	2
Baltic rush	Juncus balticus	Bareroot	120	
Pacific silverweed	Argentina egedii	Bareroot	20	
Dune wild rye	Leymus mollis	Bareoot	300	
Sea plantain	Plantago maritima	Bareroot	20	3
Oceanspray	Holodiscus discolor	1 gal	35	
Salmonberry	Rubus spectabilis	1 gal	35	
Nootka rose	Rosa nutkana	1 gal	40	
Snowberry	Symphoricarpus albus	1 gal	35	
Salal	Gaultheria shallon	1 gal	30	
Sitka willow	Salix sitchensis	Livestake	35	
Tall oregon grape	Berberis aquifolium	1 gal	30	
Osoberry	Oemleria cerasiformis	1 gal	30	
Sitka spruce	Picea sitchensis	Ball &Burlap	5	
Douglas fir	Pseudotsuga menziesii	Ball & Burlap	5	
Pacific crabapple	Malus fusca	Ball &Burlap	10	
Western red cedar	Thuja plicata	Ball & Burlap	5	
Sitka spruce	Picea sitchensis	Ball &Burlap	5	4
Douglas fir	Pseudotsuga menziesii	Ball & Burlap	5	
Total			**1,265**	

Appendix 6: Additional plant species, form and quantities installed in Phase 2 at Cornet bay

Common name	**Latin name**	**Qty**	Zone
Dune Wild Rye	*Leymus mollis*	100	2
Pacific silverweed	*Aregentina egedii*	100	
Sea Plantain	*Plantago maritima*	100	3
Scouler's willow	*Salix scouleriana*	Havested from site	4
Douglas Fir	*Psedotsuga menziesii*	2	
Tall oregon grape	*Berberis aquafolium*	10	
Beach pea	*Lathyrus japonicus*	20	
Coastal strawberry	*Fragaria chiloensis*	20	
Total		**352**	

Appendix 7: Recommended plant for installation at Bowman Bay

Common name	**Latin name**	**Form**	**Qty.**	**Zone**
Dune wild rye	*Leymus mollis*	Bareoot	200	2
Pickleweed	*Salicornia virginica*	1 gal	100	
Pacific silverweed	*Argentina egedii*	Bareroot	150	
American sea rocket	*Cakile edentula*	1 gal	25	
Coastal strawberry	*Fragaria chiloensis*	Bareroot	50	3
Coastal gumweed	*Grindelia integrifolia*	Bareroot	50	
Oceanspray	*Holodiscus discolor*	Bareroot	25	
Snowberry	*Symphoricarpos albus*	Bareoot	25	
Hardhack	*Spirea douglasii*	Bareroot	25	
Sitka Spruce	*Picea sitchensis*	Bareroot	10	4

Appendix 8: Recommended plant for installation in Phase 1 at Cornet Bay

Commone name	Latin name	Form	Qty.	Zone
Dune wild rye	*Leymus mollis*	Bareroot	100	2
Pacific silverweed	*Argentina egedii*	Bareroot	100	
Sea plantain	*Plantago maritima*	Bareroot	50	3
Coastal gumweed	*Grindelia integrifolia*	Bareroot	50	
Black gooseberry	*Ribes lacustre*	bareroot	20	
Sweet gale	*Myrica gale*	Bareroot	5	4
Pacific madrone	*Arbutus menziesii*	Bareroot	10	

Appendix 9: Recommended plants for installation in Phase 2 at Cornet Bay

Commone name	Latin name	Form	Qty.	Zone
Dune wild rye	*Leymus mollis*	Bareroot	100	2
Pacific silverweed	*Argentina egedii*	Bareroot	100	
Salal	*Gaultheria shallon*	Bareroot	20	3
Red flowering currant	*Ribes sanguineum*	Bareroot	20	
Snowberry	*Symphoricarpus albus*	Bareroot	20	
Oceanspray	*Holodiscus discolor*	Bareroot	20	
Tall oregon grape	*Berberis aquifolium*	Bareroot	20	

Appendix 10: Equipment required for data collection

Tool	Quantity*
200ft tape	2+
4ft. x 4ft. Quadrat	2+
Stadia rod	2+
Datasheets (Survivorship and Plant Cover)	20-30 double sided
Pencils	2-3
Plant ID resources (see methods)	1+
Originally installed and replanted species list	2+

*Quantities depend on the number of groups collecting data

Appendix 11: Protocol for determining plant cover at Bowman Bay and Cornet bay

1. Begin in Zone 2, the Beachgrass community. The zone closest to the sea.
2. Observe site conditions and locate the installed vegetation line. Note that this is subjective and easier to delineate in younger plantings. Use original and additional planted species lists and field observations to make the best possible judgment on where this zone begins.
3. Run the 200ft tape parallel to the sea and at the seaward edge of the entire section of the planting. Running the transect seaward of the intended sampling area allows the targeted vegetation to be sampled.
4. Choose one side of the planting section to begin sampling.
5. Take out the datasheet and write the names of the samplers, the date, transect #, quadrat number for that transect and the zone you ate sampling. In this case Transect #1, Quadrat #1 and Zone 2.
6. Choose a random number between 1 and 5 using a random number chart, stopwatch or phonebook.
7. Once you have a number measure out this many feet.
8. This is your first quadrat sample.
9. Identify all native plants (writing them into the data sheet if they are not already listed), the number of each species present and whether they are live or dead. Resources which are helpful for plant identification include Pojar and Mckinnon's, *Plants of the Pacific Northwest Coast: Washington Oregon British Columbia and Alaska*.
10. Then identify all recruited plant species, the number of each species present and whether they are live or dead. Resources used for this are *Weeds of the West* by Tom Whiteson.
11. Next count vertices to represent each cover class: native, non-native and bare ground. Do this by determining what ground cover class is represented at each point the string crosses another string. The total cover should always sum to 121 vertices. Denote this under the appropriate area on the data sheet.
12. All subsequent quadrats will be places at intervals of 16 feet until the end of the planting section is reached.
13. When the end of the planting section is reached, measure 4 feet towards the upland and run another transect.
14. Continue this sampling scheme. At the start of each transect, choose a random number (which represents the location of your first quadrat). All subsequent quadrat samples are located every 16 feet from the last until the end of the transect is reached.
15. Continue running transects 4 ft. upland from the last until the end of the planting area is reached.

Appendix 12: Protocol for determining survivorship at Bowman Bay and Cornet Bay

1. In Zone 3 and 4 of both Bowman Bay and Cornet Bay all installed plants are evaluated with a survivorship rating and the height of the plant is measured. These zones represent the Backshore shrub community and Shoreline fringe communities.
2. Start at one end of the planting area.
3. Identify the first plant and write the species code on the data sheet.
4. Measure the height of the plant with a stadia rod by placing the stadia rod next to the root crown and determining the height of the plant in feet. You will most likely have to hunch over to read plant height. Denote the height of the plant on the data form.
5. Determine if the plant was installed. This is evident by looking at the soil surrounding the plant. If the plant has a sunken "ring" around it or other signs of installation, the plant was originally installed. On the data sheet write "Y" for Yes.
6. If the plant was naturally recruited, it will NOT show signs that it was planted. The soil surrounding the individual will be undisturbed. Consider the plant species, the proximity of this plant to other species and the originally planted species list when denoting a plant as naturally recruited. On the datasheet, Denote a "N" for No, not planted.
7. Read the definitions for survivorship.
8. Note the overall health of the plant. Does it have dead portions? Are the leaves discolored which would be a sign of stress? Are their buds, flowers or fruit present?
9. Take stock of the plant, read the definitions for each survivorship rating and use your best judgment to assign a survivorship rating between 1 and 5. Denote this on the datasheet under "S rating".
10. If signs of browsing by deer is evident or any other comments that are applicable, denote this in the comments section for that plant on the datasheet.
11. Move on to the next plant.
12. Sample the entirety of both zones in this way.

Appendix 13: Datasheet for quadrat sampling at Bowman Bay

Names: **Date:**

Quadrat Number:			**Zone:**		
Plant Numbers			**Cover**		
Planted Species	**Live**	**Dead**	**Native**	**Non-native**	**Bare**
Dune Wild Rye					
Pacific Silverweed					
Coastal Strawberry					
Pearly Everlasting					
Tufted Hairgrass					
Baltic Rush					
Beach Pea					
Recruited Species:					
Toad Rush					
Pineapple Weed					
Total Dead & Alive:			**Have You Counted 121 Total Vertices? Yes☐**		

Notes:

Appendix 14: Data sheet for quadrat sampling at Cornet Bay

Names: **Date:**

Quadrat Number:			**Zone:**		
Plant Numbers			**Cover**		
Planted Species	**Live**	**Dead**	**Native**	**Non-native**	**Bare**
Salt Grass					
Lyngbys Sedge					
Dune Wild Rye					
Common Threesquare					
Baltic Rush					
Soft Rush					
Tufted Hairgrass					
Pacific Silverweed					
Coast Gumweed					
Sea Pink					
Sea Plantain					
Pearly Everlasting					
Recruited Species:					
Toad Rush					
Pineapple Weed					
Total Dead & Alive:			**Have You Counted 121 Total Vertices? Yes☐**		

Notes:

Appendix 15: Data sheet for Survivorship rating at Bowman Bay and Cornet bay

Survivorship Rating Definitions:					
1	Dead or nearly dead				
2	Live plant with dead portions and/or signs of stress				
3	Signs of new vegetative growth without reproduction				
4	Poor reproduction (Few and poorly developed flowers/fruit)				
5	Healthy reproduction (Many well-developed flowers/fruit)				
GPS Point Name:					
Site Name	**Plot #**		**Date**	**Sampler(s)**	
Planted Tree/Shrubs	Height (ft.)	S. Rating	Planted	Protector?	Comments
Additional Comments:					